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The PROGRESSIVE FISH-CULTURIST

Vol. 12 No. 3

JULY 1950

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

THE PROGRESSIVE FISH-CULTURIST

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(See inside back cover)

The PROGRESSIVE FISH-CULTURIST

News and Views from many Sources on Practical Hatchery Problems

Volume 12 | Washington, D. C. | July 1950 | Number 3

TABLE OF CONTENTS

	Page
Fish Management in the Multiple-Use Management of the National Forests --by L. W. Swift and M. A. Gee	113
Metabolic Products and Their Effects --by D. R. Brockway	127
Recent Developments in the Electric Method of Collecting Fish --by D. C. Haskell	131
Biological Effects of Nigrosine Used for Control of Weeds in Hatchery Ponds --by E. W. Surber and M. H. Everhart	135
Toxicity of Some New Insecticides to Several Species of Pondfish --by J. M. Lawrence	141
Summary of Farm-Pond Inspections, 1949 --by R. W. Sharp	147
Rainbow Brood-Stock Selection and Observations on Its Application to Fishery Management --by Cliff Millenbach	151
A Method of Transporting Fingerling Shad --by J. E. Sykes	153
Perforated Aluminum Screens for Circular Pools --by R. F. Stephens and William Evans	161
Condition Factor Alinement Charts --by C. K. Phenicie and C. G. Bishop	163
Diet Experiments on Atlantic Salmon in Maine --by G. A. Rounsefell, L. H. Bond, and G. K. White	169

Publications

Reprint:
Effectiveness of Modern Fish Management Practices: Planting --by L. L. Smith, Jr. 173

Review:
The Fisherman's Encyclopedia --edited by I. N. Gabrielson and Francesca LaMonte 180

Clearing House 181

Items

Warning to Users of Pyridylmercuric Acetate 126
Sonic Experiments Fail to Disturb Trout 150

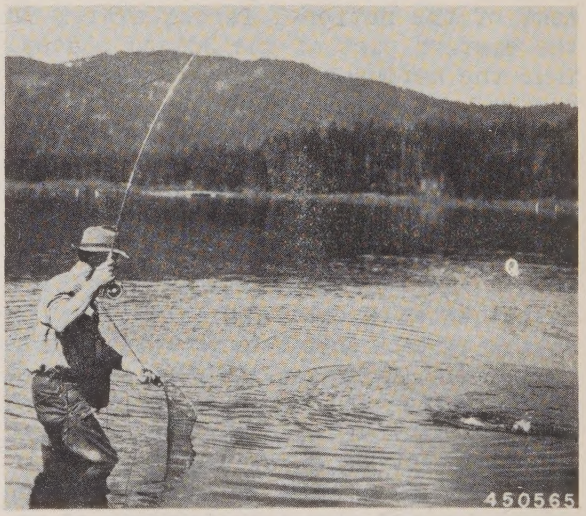
FISH MANAGEMENT IN THE MULTIPLE-USE MANAGEMENT OF THE NATIONAL FORESTS

Lloyd W. Swift and Merle A. Gee
U. S. Forest Service
Washington, D. C.

THE NATIONAL forests provide one of the largest public fishing areas in the United States. The exterior boundaries of the national forests encompass 229 million acres, of which 180 million acres is public land, owned by the United States and administered by the Forest Service. This large public property is distributed in 42 of the 48 States and in Alaska and Puerto Rico. Its total size may be appreciated by noting that it is equal to about one-tenth of the land area of the 48 States.

On these lands are extensive waters which provide good fish habitat. For the national forest system as a whole, these amount to 81,000 miles of streams and 1,650,000 acres of ponds and lakes.[1] Natural water bodies comprise most of the lake and pond area, but an important part (consisting of 376,000 acres) is formed by impoundments.

During 1949, waters on the national forests attracted 2,960,000 fishermen. The national forest waters are generally open to the public without restriction except for the observance of State fish laws, care with fire--some especially hazardous areas are closed to entry during the fire season--and other precautions which are necessary to protect the lands and keep them in an attractive condition.



(Photos courtesy U. S. Forest Service)

A high mountain lake on the Targhee National Forest in Idaho yields a fighting cutthroat trout.

Cold waters containing trout are the most important, though warm-water streams and ponds supporting bass and other species attract many fishermen. There is a wide range of types of water, varying from the warm lowland ponds of the southern areas to the rock-lined, glacier-dug lakes of the high mountains. Accessibility of these waters varies. Many miles of streams and acres of lakes can be reached by automobile. On the other hand, some of the more scenic and productive

[1] Previous statements by the Forest Service have given 90,000 miles of streams and rivers and 1.5 million acres of lakes and ponds. These figures were based on estimates of 10 years ago; the new figures are from revised estimates made during 1949.

waters are accessible only by trail, and some in remote regions are best reached by saddle horse and pack outfit.

SOME EXAMPLES OF EARLY WORK IN FISH MANAGEMENT

Actual administration of the national forests, as understood today, did not begin until they were placed under the jurisdiction of the Forest Service in the Department of Agriculture in 1905. At that time the national forests were composed of areas withdrawn from the public land areas, primarily in the Western States. In 1911, the Weeks Law provided authority for the acquisition of forest areas and opened the way for the development of the national forest system in the eastern part of the United States. Thus the national forests became truly national in scope.

Perhaps the first effort of the Forest Service to expand the fishing resource was the stocking of lakes and streams that did not have game fish. The Rangers and local people would catch a few fish from a lake or stream, place them in a bucket or milk can, and carry them by hand or by pack animal to some barren lake or stream. As hatcheries were developed by the States and by the U. S. Fish and Wildlife Service, this work was expanded and much restocking was done.

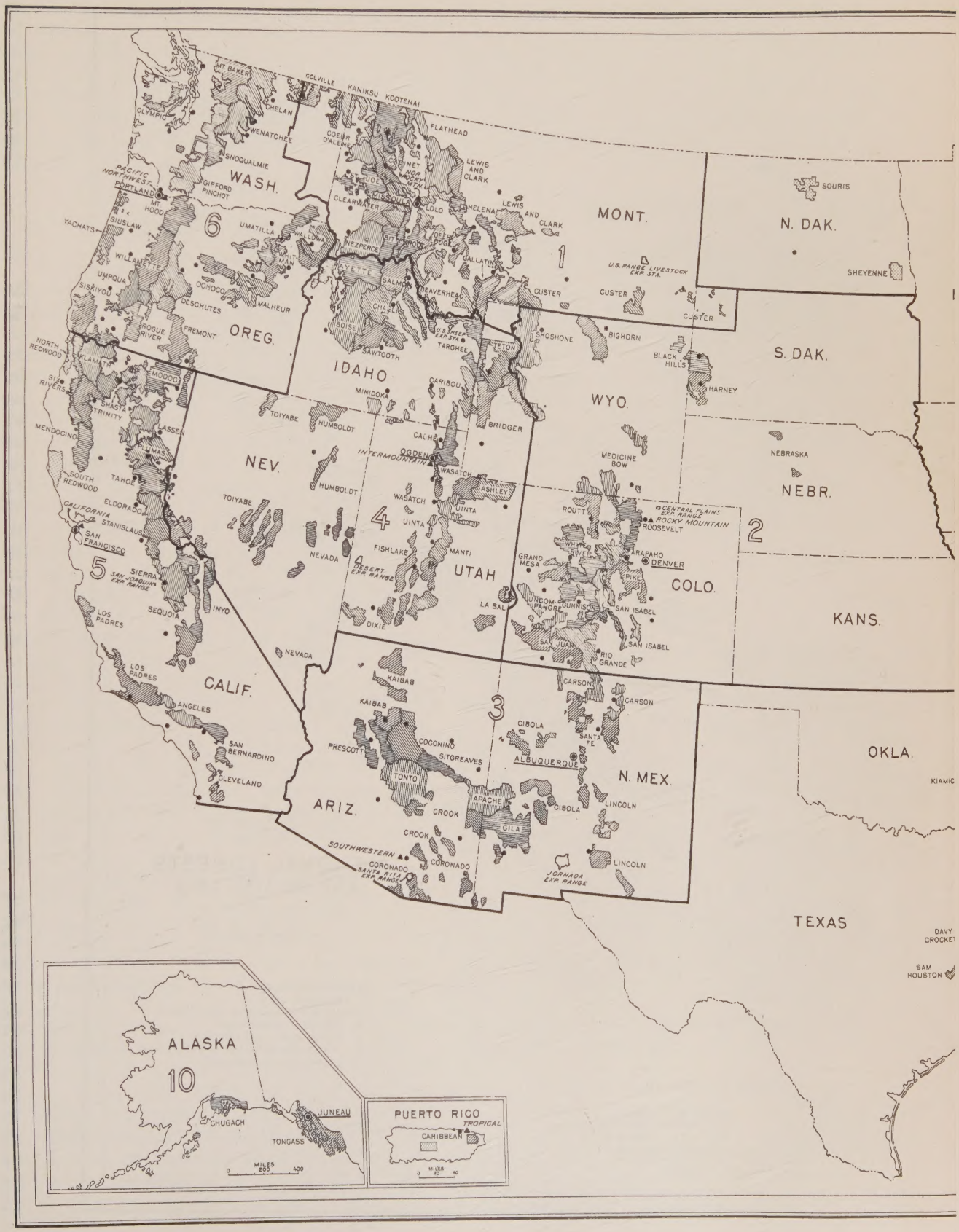
Undoubtedly, some unfortunate mixing of species and some introductions of unsuitable species took place. In some localities on the national forests, each of a series of four or five lakes may be stocked with a different species of trout; in other places, every lake may have four or five species. Sometimes the mixing of species has resulted in a situation wherein the best-adapted variety gains dominance and provides more fishing than might have been realized with native species. This, however, has not always occurred. In some of the high-altitude, cold-water streams of the Rockies, the introduced eastern brook has replaced the native cutthroat without benefit to the sportsmen. The result has been an overpopulation of eastern brook, and even the mature individuals in some streams rarely exceed 6 inches in length.

Fish stocking in national forest waters is now handled primarily by the States and the Fish and Wildlife Service. The Forest Service is active in this work in many localities, however, and cooperates with the State and Federal agencies and with the sportsmen. For example, on managed fishing areas in the Southeast, the Forest Service has constructed and maintains a number of fish-rearing stations (operated by the Fish and Wildlife Service) for restocking national forest waters. In some of the more inaccessible parts of the West, also, the Forest Service assists in restocking. Among other services, this agency provides facilities for transportation into the back country.

The effectiveness of stocking programs in the most heavily fished waters has been improved by planting adult trout during the fishing season. The Forest Service has encouraged this practice. Extensive studies of stocking problems of this type have been made in the Southeast and elsewhere in cooperation with the Fish and Wildlife Service and the States. These studies have revealed the value of planting legal-sized fish in small trout streams to supplement natural reproduction (Chamberlain and Huber 1947). The desirability of spring rather than fall stocking with legal-sized trout has been shown by these studies, as well as by other investigations made in the Southwest (Gee 1942). The Forest Service will continue general cooperation in stocking programs but will give primary attention to improvement and maintenance of fish habitat.

COORDINATION OF FISH MANAGEMENT WITH USE OF OTHER NATIONAL FOREST RESOURCES

The preservation and improvement of fish habitat are an important responsibility in the multiple-use land-management activities of the Forest Service. Briefly, multiple use under optimum conditions means that a given area of national forest will yield wood products, forage, water, and wildlife, and will also be used for recreation. This concept has been a guiding principle throughout the history of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MT. HOOD
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UMATILLA
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DEERLODGE
GALLATIN
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UMPQUA
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SALMON
BEAVERHEAD
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SHEYENNE
ROGUE RIVER
FREMONT
CHALLIS
BOISE
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YELLOWSTONE
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BLACK HILLS
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NORTH REDWOOD
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MINIDOKA
CARIBOU
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TOIYABE
HUMBOLDT
SHASTA TRINITY
LASSEN
MENDOCINO
OGDEN
INTERMOUNTAIN
WASATCH
ASHLEY
MEDICINE BOW
NEBRASKA
SOUTH REDWOOD
TAHOE
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SAN FRANCISCO
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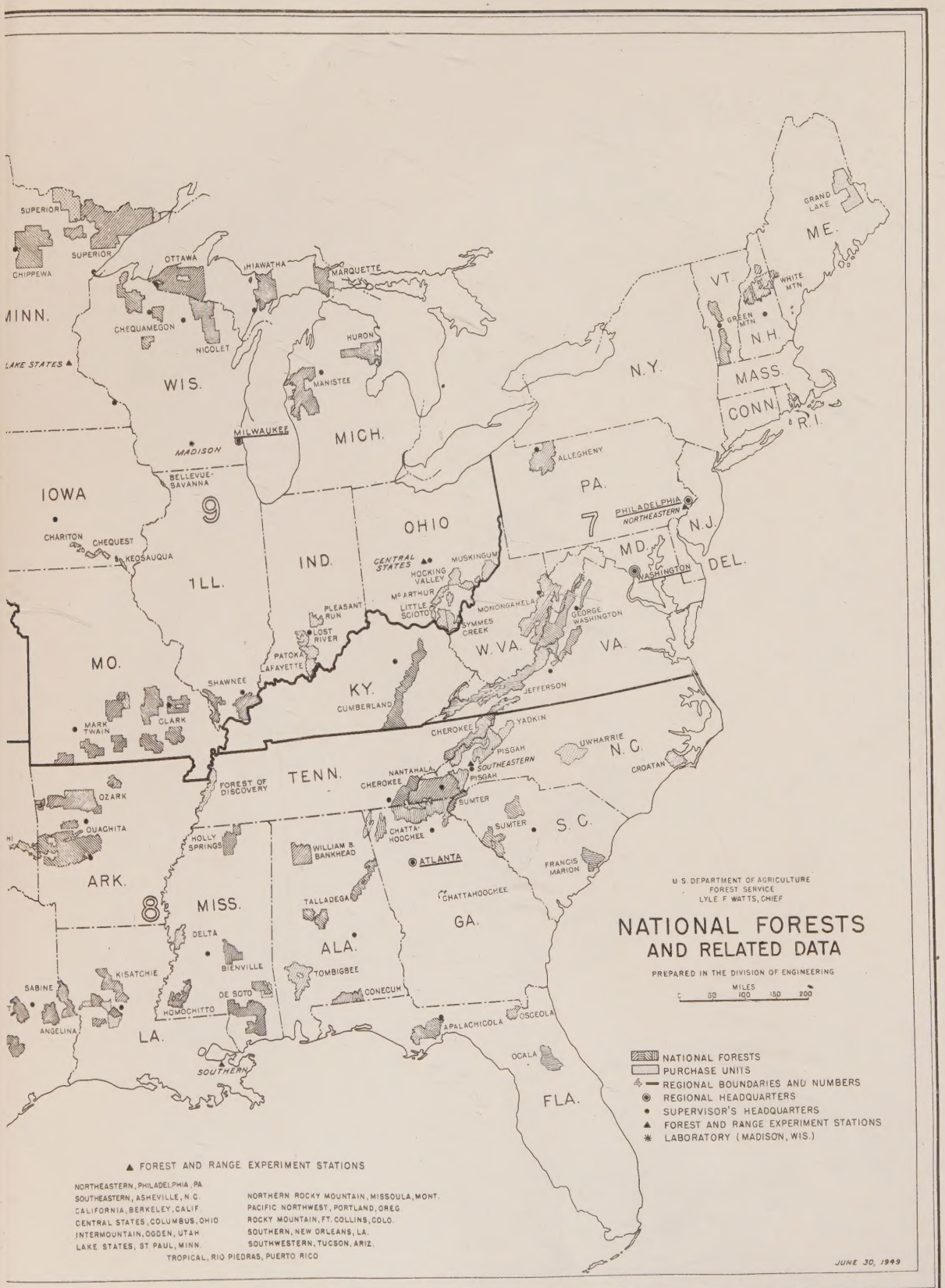
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MADISON
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BELLEVUE-SAVANNA
IOWA
9
CHARITON
CHEQUEST
KEOSAUQUA
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MUSKINGUM
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OZARK
OUACHITA
HOLLY SPRINGS
WILLIAM B. BANKHEAD
CHATTA-HOOCHEE
ATLANTA
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S. C.
FRANCIS MARION
ARK.
8
MISS.
TALLADEGA
CHATTAHOOCHEE
GA.
DELTA
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REGIONAL BOUNDARIES AND NUMBERS
REGIONAL HEADQUARTERS
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▲ FOREST AND RANGE EXPERIMENT STATIONS
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SOUTHEASTERN, ASHEVILLE, N.C.
CALIFORNIA, BERKELEY, CALIF.
CENTRAL STATES, COLUMBUS, OHIO
INTERMOUNTAIN, OGDEN, UTAH
LAKE STATES, ST. PAUL, MINN.
NORTHERN ROCKY MOUNTAIN, MISSOULA, MONT.
PACIFIC NORTHWEST, PORTLAND, OREG.
ROCKY MOUNTAIN, FT. COLLINS, COLO.
SOUTHERN, NEW ORLEANS, LA.
SOUTHWESTERN, TUCSON, ARIZ.
TROPICAL, RIO PIEDRAS, PUERTO RICO
JUNE 30, 1949

the Forest Service. Its application may, of course, require more intensive management of some resources than of others, depending on their relative importance. In comparison with management for a single use, the multiple-use concept of management yields greater total benefits to the public.

Timber Management

The close coordination between timber activities and fish management is an example of the effort to obtain multiple use. Standard timber sale instructions provide that sales will be conducted in such a manner that stream conditions will not be unduly disturbed. As an over-all requirement, timber sales must be laid out in such a way that excessive run-off and erosion will not result. This in itself is a major factor in maintaining fish habitat. With regard to protection of the stream, most logging contracts specify that the stream channel is not to be disturbed by falling trees into the channel or by dragging them along or across it. Moreover, where stream-bank maintenance and shade are important, the timber sale contracts may specify no cutting along the channels, or that cutting be modified to protect the shore lines and to retain shade. If a timber purchaser maintains a sawmill on the national forest, he is required to provide streams and lakes with adequate protection from pollution by sawdust or other material. He must also abide by rigid restrictions in the use of fire.

As an example of the care exercised in protecting the fishery resource, the following precautions taken in Alaska are cited: (1) An inspection by the Fish and Wildlife Service of the proposed sale area and planned cutting methods. The purpose is to obtain from that agency suggestions for protective measures or concurrence in the planned operation. (2) No direct tractor skidding up or down stream beds. (3) Limitation of the number of stream crossings by logging operation. (4) Prohibition of skidding of logs across the stream bed except by prior specific approval of the officer in charge. (5) Clean-up of stream beds during and after the logging to remove logs or debris accidentally or necessarily placed there. (6) Suspension of logging during the spawning season to avoid interference with the upstream salmon movement when such measure is desirable in the judgment of the officer in charge.

Range Management

Protection and restoration of the fishing habitat are also being considered in the administration of grazing on the national forests. There are many areas where overuse of the range has resulted in exposure of the soil surface with subsequent sheet and gully erosion and damage to the stream habitat. Through control of grazing, vegetation is being returned to many stream borders. On some areas range reseeding, fencing, and erosion control are being used to hasten the recovery. This is a continuing job that will occupy the interest of the Forest Service indefinitely.

Fire Control

The destructiveness of uncontrolled fire to watershed values is so well known that it needs little elaboration. In passing, however, it may be stated that fire alone has done great damage to fish habitat on a number of national forest areas. A picture that accompanies this article shows typical damage. Because of a strong and effective program of fire protection and control, burned-over areas are being revegetated and stream restoration is taking place. In addition, the fire-control program is preventing the occurrence of destructive fires in other drainages that are now in a healthy condition. The objective of the Forest Service is to hold annual fire losses to less than one-tenth of one percent of the total area under protection.

Engineering

It is well known that improperly designed and poorly built roads and trails contribute vast amounts of silt to the

NATIONAL FOREST FISHING WATERS

As of June 30, 1949

Region and State	Miles of Stream	Acres of Lakes		Total Acres of Lakes
		Natural	Artificial	
Region 1				
Montana	8,450	37,021	18,987	56,008
Idaho	4,408	124,904	-	124,904
Washington	436	3,815	140	3,955
South Dakota	-	-	-	-
Total	13,294	165,740	19,127	184,867
Region 2				
Colorado	8,297	13,415	14,108	27,523
Nebraska	-	-	-	-
South Dakota	685	-	1,134	1,134
Wyoming	2,848	8,777	227	9,004
Total	11,830	22,192	15,469	37,661
Region 3				
Arizona	731	4,082	33,424	37,506
New Mexico	524	68	202	270
Total	1,255	4,150	33,626	37,776
Region 4				
California	375	2,450	430	2,880
Colorado	7	-	50	50
Idaho	5,944	8,626	17,585	26,211
Nevada	1,061	138	77	215
Utah	2,472	10,322	8,468	18,790
Wyoming	1,431	37,080	330	37,410
Total	11,290	58,616	26,940	85,556
Region 5				
California	11,703	44,028	83,773	127,801
Nevada	-	-	-	-
Total	11,703	44,028	83,773	127,801
Region 6				
Oregon	6,325	37,420	16,487	53,907
Washington	4,488	65,090	24,493	89,583
California	95	22	-	22
Total	10,908	102,532	40,980	143,512

(continued)

NATIONAL FOREST FISHING WATERS (Continued)

As of June 30, 1949

Region and State	Miles of Stream	Acres of Lakes		Total Acres of Lakes
		Natural	Artificial	
Region 7				
Kentucky	308	-	-	-
Maine	21	8	-	8
New Hampshire	630	689	172	861
Pennsylvania	524	-	320	320
Vermont	222	1,409	10	1,419
Virginia	640	-	112	112
West Virginia	1,920	-	-	-
Total	4,265	2,106	614	2,720
Region 8				
Alabama	546	185	165	350
Arkansas	1,169	-	1,516	1,516
Florida	515	22,752	-	22,752
Georgia	886	-	8,430	8,430
Louisiana	175	-	5,053	5,053
Mississippi	489	578	18	596
North Carolina	1,920	5,000	19,486	24,486
Oklahoma	350	-	80	80
South Carolina	630	-	80	80
Tennessee	316	-	1,627	1,627
Texas	359	40	168	208
Total	7,355	28,555	36,623	65,178
Region 9				
Illinois	370	329	602	931
Indiana	220	-	18	18
Michigan	3,095	75,487	21,362	96,849
Minnesota	2,070	534,414	81,840	616,254
Missouri	992	-	7,101	7,101
Ohio	139	-	340	340
Wisconsin	1,561	54,118	6,370	60,488
Total	8,447	664,348	117,633	781,981
Total, United States	80,347	1,092,267	374,785	1,467,052
Region 10				
Alaska	1,026	180,397	901	181,298
Total, All National Forests	81,373	1,272,664	375,686	1,648,350

Unstable stream conditions are commonly associated with burned or disturbed watersheds.

This rock stream-improvement dam has been in place for many years on the George Washington National Forest in Virginia.

drainage systems. The Forest Service engineering organization is constantly striving to improve old roads and to build new ones in such a manner that erosion is held to a minimum. General practices followed in constructing roads provide for (1) leaving a fringe of timber and brush along the stream to provide shade; (2) leaving overhanging brush, trees, banks, and rocks to provide hiding places for fish; (3) keeping large quantities of construction debris out of streams; (4) avoiding channel changes that may be harmful to fish life or may result in erosion-control and bank-protection problems beyond the immediate vicinity of the change.

Through skillful coordination, engineering work sometimes makes substantial contributions to the fishing resources on the national forests. For example, fishponds have been created by constructing road fills in such a manner that they provide permanent dams. In some areas borrow pits have been so laid out that, instead of remaining as unsightly excavations, they became ponds which, after stocking, provided good fishing.

Watershed Management

Silting of streams on damaged watersheds may impair the productive capacity of fishing waters as much as municipal or industrial pollution. Moreover, restoration of the productive capacity of silt-laden streams may be much slower.

The relationship of stream productivity to watershed conditions is generally accepted even though it has not been subjected to adequate research. On a watershed protected by forests, the capacity to absorb water is relatively high and a large volume of water is stored in the ground where it may be released gradually through seepage and spring flow. Poorly protected watersheds allow large amounts of water to run off the surface and carry soil in suspension. This soil acts as an abrasive that scours plants and animals from the stream channel, and the flash flood itself provides little ground water for sustained flow during dry periods. Thus, fishing streams reflect very closely conditions on the watersheds from which they flow.

The interrelationships between watershed conditions and stream productivity are well illustrated by changes that are occurring in the Ozark region. In the past, these lands were severely abused by overcutting, burning, and overgrazing. Under administration by the Forest Service, these abuses have been corrected. As a result, streams which were formerly subject to violent fluctuation, scouring, and shifting of channels now show signs of stabilization. This change has been accompanied by a noticeable increase in game fish.

Another example of the relationship of watershed condition to stream condition is found in the history of North Creek on the Jefferson National Forest in Virginia. Persons living in that area have observed the following shifts: North Creek was once a popular trout stream. It became virtually barren of fish after the watershed had been logged and burned. Frequent flash floods cut new channels and obliterated pools. During dry periods the creek ceased to flow. Nearly 40 years ago land in this area was placed under national forest administration and steps were initiated to restore the watershed. Today North Creek shows substantial recovery and is again providing good trout fishing.

Recreation

The maintenance of natural fish-habitat conditions has been helped by establishing wilderness and wild areas under authority of the Secretary of Agriculture. Wild areas are at least 5,000 acres, but wilderness areas are more than 100,000 acres in size. Primitive conditions are preserved, motor travel is excluded, and cabins and other developments are prohibited. In this land category are such well-known areas as the Bob Marshall Wilderness Area on the Flathead and Lewis and Clark National Forest in Montana, the High Sierra Wilderness Area in the southern Sierras in California, and many other attractive high-mountain sections of the West. The 77 wilderness and wild areas amount to about 14 million acres. These special classifications help to

retain the back country for the many Americans who like to go by foot, horseback, or canoe to the more remote country. In addition to being very attractive, these areas provide some of the finest fresh-water fishing in the United States.

The recent Executive Order creating an air-space reservation over the Superior Roadless Area of the Superior National Forest in Minnesota was a significant step in the guardianship of that primitive country. It is the first reservation of this kind in the history of the United States and provides that after January 1, 1952, no planes shall be permitted to land in this area, nor to fly at elevations of less than 4,000 feet over it, except in case of emergency. This reservation helps to maintain the wilderness aspect of the canoe country and, of course, will also help to prevent depletion of the fishing resource. Airplane parties can fly into a remote lake, take limit catches of game fish, and fly out with them the same day without loss from spoiling. Canoe parties cannot do this; most of them keep only the number of fish they can eat, returning the rest of the catch to the water. Air transportation for parties, as compared with canoe travel, also has the drawback of concentrating a greater fishing effort on remote waters.

Wildlife Management

Conflicts between different species of wildlife sometimes occur. For instance, the presence of beaver in some places conflicts with trout management. Flowages above beaver dams in some areas have caused water temperatures to increase to a point where habitat was unfavorable to trout. Elsewhere, beaver have cut streamside vegetation which was important in maintaining desirable water temperatures. On the other hand, in high mountain streams where water temperatures are usually low, beaver impoundments have frequently been beneficial to trout by warming the water and providing more water area. Increased acidity in beaver ponds, resulting from the flooding of a large amount of vegetation, may be a factor in decreasing fish-food production. When conflicts in management arise, each case must be decided on its merits. This requires constant checks by the Forest Service and cooperative action with State officials.

Coordination through Other Agencies

In addition to the correlation activities of the Forest Service, certain recommendations made by the Forest Service for maintenance of the fishing resource have been adopted by other authorities. Such a case was the recent ruling by the Federal Power Commission, which required that a power company in California bypass sufficient water to keep part of the river in an attractive condition for recreational use. This is significant because the requirement was added to the renewal of a less restrictive permit that had been in existence for 50 years. It indicates a growing recognition of the recreational use of the water resource of the national forests.

The Forest Service is working with the Fish and Wildlife Service and with the States in an attempt to provide sufficient minimum pool levels in irrigation and power reservoirs to sustain fish life, and to see that sufficient water is released in streams below dams and diversions to maintain fish life.

The importance of coordination of resource uses on the national forests cannot be overemphasized. Any wildlife program must start with a suitable habitat for wildlife as a goal. Any practices that are harmful to wildlife food and cover conditions undermine the very foundation of a wildlife-management program. The activities of the Forest Service in timber management, range management, watershed management, fire control, engineering, and recreation tend to stabilize and improve the wildlife habitat and are positive steps in behalf of fish and game work.

THE FOREST SERVICE RESEARCH PROGRAM

The Forest Service is the Federal agency primarily responsible for forest and range research in the United States. Research activities are carried on at 11

regional experiment stations, with 103 experimental forests and ranges scattered throughout the United States, Alaska, and Puerto Rico. This research work is of fundamental importance to the Nation's fresh-water fishery resource because it develops the forest- and range-management techniques by means of which the coordinated multiple-use resource-management program is carried out.

New methods and techniques developed by research are worked into the pattern of resource management as soon as their economic feasibility and practical values have been demonstrated. Among these are new methods of reseeding depleted ranges and reforesting timberlands destroyed by fire or destructive use. Direct improvement of vegetative cover is, of course, necessary if good watershed conditions and the intimately related good stream habitat are to be maintained.

Research in fire control has resulted in improved methods of fire-danger measurement and the development of special fire-fighting techniques that employ modern mechanized equipment. Fire records show that this has resulted in a greatly increased saving in burned-over acreage each year. Because national forests are usually located in high water-producing zones, improved fire-control techniques have undoubtedly resulted in the saving of large watershed areas and their lake and stream habitat.

The relationships between forest cover and stream flow are being ascertained through research on forest influences. Such factors as fire, grazing, and timber cutting, which alter stream flow through their effect upon vegetation and soil, are becoming better understood. Forest management is developing methods for the use of the timber resource, and there is indication that stream flows can be improved by special silvicultural practices.

The importance of Forest Service research is stressed here because it is mainly through such research that the many problems in forest, range, and watershed management will be solved. These problems are, of course, closely related to fishery management. The results of such research are available to fishery administrators everywhere and are not limited to use on the national forests.

DIRECT MEASURES FOR HABITAT IMPROVEMENT

Stream Improvement

Efforts to improve streams by the installation of special stream-improvement structures were given emphasis during the days of the Civilian Conservation Corps and other emergency work programs. On the basis of experience obtained through these emergency work programs, the Forest Service, Fish and Wildlife Service, and certain States prepared stream-improvement handbooks. Some of the early work done on the national forests was poorly planned, both as to the location of the stream-improvement structures and as to the engineering principles involved. As the program continued, however, the quality of the work improved noticeably. It was found that the simpler types of log and rock structures were very stable. On many miles of stream these installations have remained in place and performed a very worthwhile function.

The design of the structures and the materials used varied considerably. Low log dams were one of the commonest types used in mountain streams, and they were very effective when constructed so as to preclude undercutting or washing around the ends (Fearnow 1941). Where large rocks were plentiful, dams made of them were often very satisfactory. Frequently it was found that dams became filled with gravel and silt, and that the scouring action of the water pouring over the dam formed a pool; however, where stream channels were stable and not subjected to severe scouring action by floods, the pools created above the dams remained for many years. Deflector types of improvement were used in some waters, particularly where such devices could be used to scour the loose sand or gravel and provide a pool. These deflectors were of various types: some were made of logs, others of log-stone cribs, and still others consisted of a wire-basket, rock-filled installation.

It is appreciated, of course, that stream improvements are not the whole

answer to maintaining desirable fish habitat. Stream improvements have distinct limitations. For instance, it is not regarded as feasible to place stream improvements in large streams or rivers. The reasons for this are twofold: large volumes of flow would require extremely expensive construction work, and large volumes in themselves usually provide satisfactory shelter for fish. Therefore, stream-improvement work, on the national forests at least, is limited to the smaller streams. Many streams on the national forests appear to have satisfactory channel conditions and a desirable proportion of pools and riffles. There are many streams, however, where stream-improvement work would be beneficial to fish life. These include streams that are deficient in pool area because of extensive areas of sandy flats, shallow riffles, or bedrock.

A special method of stream improvement was developed in the Sierra-Nevada Mountains in California some 20 years ago in cooperation with the State Fish and Game Commission and the local sportsmen's association (Needham 1938). In this section the high-elevation streams are subjected to great variations in volume of flow. Following the spring snow melt, the flow is very high; but by fall it is intermittent and, in some areas, water is confined to a few of the deeper pools. This situation is the result of the general watershed conditions where a high percentage of impervious granite is exposed, and consequently there is little opportunity for water storage in the soil and subsequent percolation into the drainage systems.

The plan of improvement developed for the Sierra-Nevada high-elevation streams involved the construction of low rubble dams in the outlets of small glacier-formed lakes at the headwaters of streams to provide additional storage capacity. A drainage pipe was installed in the dams, and the surplus water was released into the stream channel during the dry season of June to October. In this way a year-long flow was maintained in the streams. Since habitat conditions and especially spawning beds were improved, the resultant response by fish life has been very satisfactory. This type of stream improvement has been regarded as particularly successful in the Sierra-Nevada Mountains and has gradually been extended to other national forests in that area, primarily in cooperation with the California Fish and Game Commission. Undoubtedly, it would have application in other regions where the same type of watershed conditions and fluctuating run-off prevail.

Lake Improvement

In addition to retaining the natural conditions of existing lake waters, considerable acreage has been added by impoundments. In a number of places this is the result of irrigation and hydroelectric developments, both public and private. In many places, however, small water bodies have been created by the Forest Service specifically for recreational use, including fishing. A few of these lakes are relatively large, as, for example, the 400-acre Lake of the Pines in South Dakota and the 170-acre Vesuvius Lake on the Wayne Forest in Ohio. These impoundments have usually been located where there is a high demand for outdoor recreation. The public use of these waters normally exceeds that of the natural bodies. In all, there are on the national forests about 380 artificial bodies of water, including those built for power and irrigation.

As part of the lake-improvement activity of the Forest Service, some natural lakes which were of insufficient depth and subject to winterkill have been deepened by appropriate impoundments. This normally has been an inexpensive method of providing better fish habitat. There are still opportunities along this line. A few lakes with an insufficient water supply have been improved by diverting water into them from nearby drainages.

A problem on many water bodies, particularly in the warmer areas, has been that of weed control in lakes and ponds. Various methods of control have been considered in cooperation with the States and universities. This work has included application of fertilizer to produce a bloom, as well as spraying with 2,4-D or other herbicides to kill the plant growth. Where feasible, attempts have been made

to give permanent correction to the weed problem by deepening the lakes through dam construction.

SPECIAL FISH MANAGEMENT PROGRAMS IN COOPERATION WITH THE STATES

Throughout the national forests, strong cooperative relations are maintained with the States. Some of the most interesting cooperative programs dealing with fish management have been developed in the Southeast. These programs usually involve regulated fishing wherein the State collects a special fee of one dollar per fisherman-day. To provide most satisfactory conditions, fishing is permitted on alternate days or several days during a week so that the fish are not subjected to constant fishing effort. In addition, the number of days a stream is opened during the season is based on estimates of its natural production plus the number of fish that can economically be stocked in it. Careful surveys of the streams determine the normal production of wild fish. Then, on the basis of the known fishing load and a program designed to provide a satisfactory yield per fisherman, legal-sized trout are stocked to make up the difference. Usually the adult trout are produced in a rearing station constructed with emergency funds by the Forest Service and operated by the Fish and Wildlife Service or by the State.

Two rivers that, together with their tributaries, are managed under such a program are the Tellico River on the Cherokee National Forest in Tennessee and the Davidson River on the Pisgah National Forest in North Carolina. Constant attention to the number of fish stocked and to the number caught has apparently made the program very successful.

The quality of the fishing and its popularity are indicated by the following record for the 1949 fishing season on two of the national forests in the Southeastern region:

National forest	Man-days of fishing effort	Total number of trout caught	Average catch per man-day
Nantahala	4,128	22,676	5.49
Pisgah	16,429	77,034	4.68

CONCLUSION

This paper is purposely general in nature. It is intended to present an over-all picture of the policy and the programs which the Forest Service is fostering to maintain and improve the fishing resource. In line with Forest Service policy, water is regarded as having multiple uses in common with other resources. Water can be used for power, irrigation, culinary purposes, recreation, and for the production of fish and other aquatic life. Multiple use may mean some reduction in the strictly economic uses, as power and irrigation, because public benefits dictate that water has other values. It is the desire of the Forest Service, therefore, to see that all waters on the national forests contribute to the overall needs of the people and to the economy of the country.

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WARNING TO USERS OF PYRIDYLMERCURIC ACETATE

In using pyridylmercuric acetate (PMA) for the control of gill disease by pond-treatment methods, a precautionary measure has been found necessary in certain ponds of the Colorado Game and Fish Commission.

W. R. Seaman, fish technician, reports that if water which contains PMA cannot be prevented from entering a pond of fish that are not to be treated, it is imperative that these fish be given no food and that unused food be not dislodged by sweeping the pond within 24 hours. Several of their hatcheries have a pond system in which it is impossible to deflect the water of a treated pond from lower ponds that contain fish. On two occasions there have been losses of trout that ingested PMA on food. The stomachs of these trout swelled enormously with gas, and the fish exhibited much distress and pain.

METABOLIC PRODUCTS AND THEIR EFFECTS

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THE RELEASE of body energy, the building and repair of the body parts, and the excretion of waste materials--all are included in the word metabolism. The products of metabolic activity must be eliminated from the body because they are, or may become, toxic to the animals producing them. These wastes, in the case of fish, are eliminated directly into the water in which the animal must continue to live. In the wild, the ratio between the water volume and the amount of these metabolic products is so great that they are immediately diluted to a harmless concentration. Under hatchery conditions, however, where the concentration of fish is so increased, particularly where ponds are operated in series, the dilution factor is greatly reduced and external toxicity may result. These products are very soluble in water, and because they are not lost to any appreciable extent through aeration, they are carried from one pond to the next. Consequently, the more often the water is used, the more chance there is that these metabolic products will build up to harmful levels. During the past few years an effort has been made to determine the effects of the waste or metabolic products upon the fish and to devise methods of control.

In fish, excretion of metabolic products occurs mainly through the gills. The products eliminated by this route include ammonia, urea, and amine and amine-oxide derivatives. The remaining products, which include creatine, creatinine, and uric acid, are excreted through the kidneys.

Ammonia is one of the chief products of protein metabolism in trout, and it has been shown that fish are very sensitive to both ammonia and ammonium compounds (Ellis 1946). In field work, 1 part per million of ammonia is taken as definite indication of pollution. Wuhrmann (1948) states that 0.1 part per million is the maximum that should be tolerated in waters used for fish culture.

In the preliminary work reported in this paper, ammonia was used as the criterion of the concentration of these products. Ammonia was chosen because of the ease and speed with which this substance could be analyzed. Ammonia, itself, may not be the culprit, but there is reason to believe that the other metabolic products will fluctuate proportionately. While in the resting state, a trout excretes ammonia at a fairly constant rate. This rate, however, increases with the activity of the fish and with a rise in water temperature, as well as immediately after feeding. A rise of 13° in water temperature (47° to 60° F.) may cause a tenfold increase in the rate of excretion. If the products are allowed to accumulate, they may exert a detrimental effect on the fish.

As the ammonia concentration rises, the fish lose the ability to use oxygen and the blood picture becomes drastically altered. As the concentration of ammonia increases in the water to approximately 1 part per million, the oxygen content of the blood decreases to about one-seventh of its normal value, and at the same time the carbon-dioxide content of the blood increases about 15 percent. In other words, the hemoglobin of the blood loses the ability to unite with oxygen or to liberate carbon dioxide. Because of this failure in the ability to utilize available oxygen, the fish actually suffer from suffocation.

The excretory product of respiration is carbon dioxide. It has been shown (Irving et al., 1941) that this exerts a similar effect. As the carbon-dioxide tension in the blood increases, there is a decrease in the utilization of oxygen. Any increase in temperature also aggravates this effect. Thus, we have two substances which, when allowed to accumulate, upset the normal metabolism of fish. Carbon dioxide, however, may be eliminated from the water very readily by aeration.

When the ammonia concentration of the water reaches 0.3 part per million, a decrease in the oxygen content of the blood may be noted in analyses. The oxygen content of the blood decreases rapidly as the ammonia concentration rises beyond this point. It may well be that lower concentrations are adversely affecting the fish and that we, as yet, are unable to recognize these effects. Ammonia or other products of metabolism that may be present change the environment, and the fish have to make a physiological adjustment to this change. If the normal metabolic rate is affected, probably growth rates are altered and other normal physiological functions are upset even though there is no great increase in mortality. The control of these harmful products involves either the reduction of fish weight per cubic foot of water or an increase in water flow through the pond sufficient to dilute these products to a harmless concentration. Because of this, it behooves us to change our traditional way of thinking. To date, little concern has been given to the relationship between the volume of water in a pond and the flow of water through that pond. One of the easiest ways to correlate these two factors is to think of a pond and its water supply in terms of water changes per hour, which also will indicate the rate of dilution that is being obtained.

As might be supposed, the danger from the effects of accumulated metabolic products is greatest during the summer, when the water temperatures are the highest and the amount of water available is limited. The danger is also increased when ponds are being operated in series. Here the products are being carried from one pond to those below, and higher concentrations are found in the lower members of any series. This may be the answer to heretofore unexplained mortality in the last members of a series of ponds even though the oxygen content of the water is sufficiently high to allow normal metabolism. In one production hatchery, values were found which indicated ammonia concentrations as high as 0.9 part per million in the last of a series of five ponds. In this particular instance, the water temperatures were over 60° F. and the rate of water change was less than one per hour.

The control of metabolic products by decreasing the fish weight per unit of water is feasible but often not practical. When the fish weight per pond is cut, more ponds have to be available to receive the fish removed. In a production hatchery, all the pond space ordinarily is filled. If ponds must be left empty for future population expansion, the overall production of the hatchery will, of necessity, have to suffer. This method of control may be satisfactorily employed, therefore, only in those specific instances where the hatchery is not being operated to capacity.

To insure greater dilution of metabolic products, the rate of water change may be increased by diverting more water through the system. Usually, particularly in the East, all the available water is utilized during this period of the year, so that the use of this control method is prohibited. Sometimes, however, a better-planned distribution of the available water may ease a particular situation. If several series are being operated, it may be advantageous to divert more water through a series of ponds that may be more heavily stocked. Equal distribution of water between series, when they are stocked at the same rate, may also be beneficial.

If these two methods are not applicable, the third method, in which the water level in the ponds is lowered, then becomes the only alternative. As the water level is lowered, the weight of fish per cubic foot of water is increased, but the resultant greater dilution of the metabolic products is sufficient to overcome the weight increase. The low level need be maintained only during the

periods of extreme hot weather and low water.

The lower the water level in a pond, the greater assurance there is that each calculated change per hour is a complete change. Because the excretory products in solution are heavier than water, they do settle to the bottom. When the water in a pond or raceway is deep, the fresh water entering the system tends to stratify and flow off in a surface layer, thus failing to dilute the waste products accumulating in the bottom layers. In one series of ponds approximately 15 by 50 feet, having a water depth of 24 inches and 0.9 change of water per hour, the ammonia content of the water was 0.76 part per million when the ponds were stocked at the rate of 1 pound of fish per cubic foot of water. It was found, however, that when the water level was lowered to 12 inches and the rate of change was thereby increased to 1.8, the ammonia concentration was reduced to 0.3 part per million.

During these periods of extreme conditions it is also well to limit the food, perhaps by feeding only half as often. Under these conditions the fish may not feed so well, and any uneaten food that is allowed to accumulate and decompose may further aggravate the situation by adding decayed matter or other products to the water.

At present the ammonia determinations entail the use of a photoelectric colorimeter. It is hoped that other satisfactory methods which can be applied by the hatchery personnel will be found. If such methods are found, each hatchery will be able to keep ammonia concentration records. Then, when trouble threatens, the hatchery can make the necessary adjustments in water level or rate of flow. Data indicate that during extreme conditions of temperature or low water the normal metabolism of the fish is endangered unless the ammonia content of the water is kept below 0.3 part per million. During cold weather little trouble should be experienced.

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Stream improvement may be less spectacular than stocking or than cutting down on the "take," but it's a mighty effective program for turning a "fished-out" stream into fine trout water.

-- frustrated?

Freemont, Ohio
April 1, 1950

THE PROGRESSIVE FISH-CULTURIST
Washington, D. C.

Gentlemen:

Subject: Bass Stocking

I see that most of the technical fellows say that it doesn't pay to stock bass. This is unfortunate because all evidence gathered by our private hatchery staff shows that it does pay. Here are three examples:

1. We planted 1,000 bass fry in a 50-acre lake. Bass fishing went downhill the next several years, but crappie fishing improved a lot. Since there is no other explanation for the improved fishing, our stocking with bass must have been responsible.

2. In another case we planted 1,000 bass fingerlings in a lake. These were hatched earlier than the bass born in the lake. When we introduced our fish, they started right in eating the natural ones--and probably ate them all. Fishing hasn't been very good since, but if it hadn't been for our hatchery fish there wouldn't have been any fishing because the others were eaten up. In this lake the hatchery bass were supporting the full fishing load.

3. In this same lake one year we seined up 500 small natural bass fry before stocking with ours. We cut a notch in one fin of each--a small one so it wouldn't hurt them. We never told anyone about this because that might make the fishermen prejudiced. Human prejudice can influence the results. This was three years ago, and no one has yet called us to say that he has caught a notched-fin bass. This shows that they have been catching only hatchery bass.

I am sure these examples will stop some of the comments on the value of stocking.

Yours sincerely,

An Ardent Believer.

P.S. This isn't about bass stocking, but it does show that we need to know something about animal behavior. For several years we tried to cross eels and water snakes without success. Then one year we were successful. The offspring did well, but after five years things began to happen. They started swishing madly about the pond. They wouldn't eat. Finally they all died. What happened was this: their eel instinct told them to go to the ocean to spawn; their snake instinct told them to stay near the hatchery to lay their eggs. They were so torn between two strong desires that they all died of nervous frustration.

RECENT DEVELOPMENTS IN THE ELECTRIC METHOD OF COLLECTING FISH

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THE USE of the electric shocker for stream census work in New York State was reported first at a meeting in January 1939, more than 11 years ago. It seems appropriate to review the various developments which have appeared since that time and, if possible, to reconcile the various techniques. It is interesting to note that many of the techniques which have been reported are still in use, each popular with certain workers. This, the writer believes, reflects the fact that size and depth of stream and type of soil and water have a great effect upon the operation of the shocker. For best utilization of the method, one should be equipped with a variety of techniques and should select the appropriate technique for each environment.

The first shockers, as reported by Haskell (1940), used a long electrode at the water surface and depended upon a ground connection for the other electrode. The current flow in this method is, in general, vertical from the electrode to the stream bottom. The voltage gradient, or volts per foot, which determines the effectiveness of the shock, depends upon the available voltage and the depth of water. For general use, 230 volts A.C. is practicable in depths to about 4 feet. The bottleneck of this method (not always recognized) is that as the current has to return to the generator through the soil, a portion of the voltage available at the generator is used up in the soil and is not available in the water for shocking. For example, if 230 volts were available at the generator and 40 volts were lost in the ground part of the circuit, then only 190 volts would be left for the useful portion of the circuit in the water. The success of the ground system depends upon the relative resistance of the soil and water. In general, the accompanying table summarizes these conditions. Often the ground system will work well in one part

EFFECTS OF WATER AND SOIL TYPES UPON GROUND SYSTEM

Water	Soil	Results
Soft (high resistance)	Sand, rock (high resistance)	Variable
Soft	Mixture loam, sand, rock, clay (fairly low resistance)	Good
Hard	Sand, rock (high resistance)	Very poor
Hard	Rich farm land, muck or soil having a high mineral content	Very good

of a stream, as in flat farm land, but very poorly just a short distance away in rocky, sandy, precipitous sections. This writer still considers the ground system the simplest for many situations: where it is adaptable, it covers wide and narrow streams with equal effect over the entire width.

The development of alternatives to the ground system undoubtedly has been most important to workers in sections of hard water or to those whose work is in very wide streams and rivers. In a wide stream where a long electrode, say 30 feet, is required, the circuit in the water may be considered as roughly equivalent to the use of three separate 10-foot electrodes. With equal voltage available between the electrode and stream bottom, the 30-foot electrode will work equally as well as a 10-foot electrode. The 30-foot electrode tries to draw three times as much current, and there is roughly three times as much voltage lost in the ground; hence much less voltage is available for the water part of the circuit. For this reason, in wide streams and in conditions of hard water combined with soil of high resistance, methods other than the ground system are useful.

All the ungrounded arrangements use two electrodes connected to opposite terminals of the generator. Each system has advantages and disadvantages which it will be useful to examine.

In the system proposed by Haskell and Zilliox (1941), the floating electrode crossing the stream was retained and a second electrode, which also crossed the stream about 4 to 6 feet from the floating electrode, was used at the stream bottom. The system is very effective, but the electrode at the bottom (for which a bare wire is used) snags frequently on rocks and other obstructions. The need for this system has been indicated most often in wide streams, where electrodes as much as 50 feet in length have been used.

Wide streams, requiring long electrodes, may create a need for larger generators. As generator size is often misunderstood, a problem will be used to illustrate the terms "current," "volts," and "watts." Consider an ordinary domestic water pumping system. In one instance the pump serves a small family; in the second it also serves two neighboring houses. For the first family a fairly small pump will deliver all the water required at 40 pounds pressure. If, now, the two other families are connected to the same small pump, the pressure will drop because the pump cannot deliver sufficient water to supply the total need. A larger pump is required to deliver plenty of water at the 40-pound pressure. For the shocker, the 40 pounds of pressure correspond to the 230 volts common to all shockers. With a small generator, as the electrode is lengthened and more current is drawn, the voltage will drop because the generator is incapable of producing enough current. A larger generator is required to produce the additional current, still at 230 volts. All shockers will therefore have a rating of 230 volts and a current rating in amperes. In addition, there is a watts rating. Watts give a composite picture of the generator capacity, as the watts rating is a product of the voltage rating times the current rating. A small shocker might be rated: 230 volts, 2 amperes, and 460 watts; while a large unit might be: 230 volts, 21.7 amperes, and 5,000 watts.

Shetter (1948) used electrodes of an entirely different type. Those he used are commonly called paddles in the East. Each electrode consists of a metal surface or metal mesh fastened to a pole. An operator handles one electrode on one side of the stream and another electrode on the other side. The current path is horizontal, through the water. This method is remarkably effective. Shetter reports that it is useful in streams as much as 12 to 15 feet in width. It has one disadvantage that is worthy of note: the apparatus may appear to be working well but actually may not be doing a complete or nearly complete job of collecting fish. The situation is like that of a garden hose laid on a flat surface, where the water leaving the hose spreads rapidly. The current from the electrode spreads even more, spreading both horizontally and vertically. The spread is greatest in midstream, from which point the current density gradually increases until it is concentrated at the second electrode. It is evident that the current

density is very great near the electrode and very low in midstream. It is also true that where the current density is low, the voltage drop per unit length of path is low. Hence the voltage drop is very rapid near the electrodes and very gradual in midstream. The shocking power depends upon the rate of voltage drop. A fish near the paddle-type of electrode may be stunned readily, while a fish in midstream may not be stunned at all. To obscure the situation, a large fish in midstream may feel enough shock to cause him to move and he is likely to get closer to an electrode and be stunned; a small fish in midstream may not feel any shock, while his brother near the electrode is stunned. The foregoing is not intended to discredit the two-electrode method; rather it should cause the operator to be observant of the effectiveness in midstream, particularly when an unusually wide spot has tempted him to get his electrodes far apart. Shetter (1948) mentions the same limitation to the method.

Articles have been written to describe various types of electrodes, and some of these articles are listed at the end of this paper. All deal with either a grounded system or a two-electrode system. Some systems involve floating electrodes; others alternate a series of positive and negative electrodes. These will not be described in detail because their descriptions are available equally to the reader and to this writer; in fact, the reader may be more familiar with many of them.

In looking through the literature, it is interesting to note that in his original paper this writer, stressing the potential danger of the shocker, apparently overdid it to such an extent that Shetter was impelled to minimize the danger in his paper and Funk avoided the method for a time. Real danger exists--but only in the unlikely circumstance that someone may fall in the water under a live electrode. The voltage used is not necessarily dangerous, but voltage multiplied by time, particularly when a large area of the body is exposed, can even kill--as is evident from the occasional newspaper reports of death from 115 volts in bathtubs. In general, too, D.C. is considered somewhat more dangerous than A.C. For example, a D.C. circuit carrying a heavy current is harder to interrupt with a switch than an A.C. circuit, and D.C. shock is more apt to be accompanied by painful burns. Nevertheless, D.C., like A.C., may be used safely if caution is used.

Consideration of the D.C. shockers, as described by Rayner (1949), brings up a subject even more interesting than the ordinary A.C. methods. With D.C., the fish are attracted to the positive electrode. As is well known, one electrode is replaced by a scap net into which wire is woven; the other electrode may be a "paddle" or a floating grid drawn along behind the operators. More than one positive electrode may be used. Voltages and wattages are about the same as in A.C. systems. Because industry has standardized on 230 volts A.C. and 250 volts D.C., these are the units most readily available. With D.C., the fish swim to the electrode, precluding the necessity for chasing them. This method, however, has been observed to have the same limitation as the A.C. two-paddle system; namely, that fish, particularly small ones, midway between the electrodes may not feel the impulse which will draw them to the waiting scap.

So far as is known, the combination of A.C. and D.C. voltages in series, used by Smolian (1944), has not been tried in this country. It would seem to require two generators, one A.C. and one D.C. connected in series, each of perhaps 115 volts rating. Smolian's article (the translation obtained in mimeographed form from John Rayner) is a valuable and detailed study of the entire field.

In the January 1950 issue of THE PROGRESSIVE FISH-CULTURIST, a small "one-man" shocker is described by Robert W. Morris of Oregon. This shocker uses a "hot-shot" battery and a Model T Ford coil, or modification thereof.

The writer has a portable unit which has been used during the past summer for the first time. It is operated from a motorcycle battery and produces about 150 volts A.C. It is used with two paddle electrodes, each about 8 inches square, and these may be held about 3 feet apart (maximum). Because of the relatively small amount of power available from the

battery, the effect is disappointing in large streams and in hard water. R. G. Zilliox has tried the unit in soft water in Adirondack streams with excellent results. In other tests in harder water, the unit has worked well in small tributaries, but it is not adapted at all for general stream census work. Sometimes it can be used to get a qualitative sample of the fish population in a stream of moderate size.

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"A trout," says Professor Arthur D. Hasler of the Zoology Department of the University of Wisconsin, "can detect the difference between a perch and one of his own kind by smell. Some fish can distinguish between various fellow members in a school. This sense of smell aids the fish in search of a meal, since most substances give off an odor which spreads through the water."

BIOLOGICAL EFFECTS OF NIGROSINE USED FOR CONTROL OF WEEDS IN HATCHERY PONDS

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THE USE of aniline dye for weed control has been studied in Arizona waters by Eicher, who reported (1947) a temporary increase in phytoplankton and zooplankton in two bass ponds that were treated with nigrosine. The following preliminary experiments were conducted with nigrosine[1] at the U. S. Fish-Cultural Station at Leetown (post office, Kearneysville), West Virginia, to determine quantitatively the biological effects of its use in hatchery ponds.

POND EXPERIMENTS

That nigrosine has no harmful biological effects is indicated by the observations made in two bass nursery ponds at Leetown. On May 3, 1949, nigrosine was applied at the rate of 10 pounds to the acre to Pond H-1 (0.2 acre). On May 9, the pond was stocked with 20,000 smallmouth black bass fry to the acre. On May 13, this pond received another application at the rate of 10 pounds to the acre, but a good waterbloom appeared. On June 14, the pond received nigrosine at the rate of 5 pounds per acre and 10-6-4 inorganic fertilizer at the rate of 50 pounds per acre. On June 29, when the pond was drained, nine adult bluegills from an adjacent pond were found. The results in this pond were considered very encouraging. A waterbloom had appeared instead of the coarse vegetation which had been customary in recent seasons in this pond. Production of smallmouth bass was at the rate of 4,165 per acre or 33 pounds to the acre during a 52-day period: this was slightly above average (4,080 fingerlings per acre) for unfertilized ponds. The fish averaged 2.8 inches in total length. The survival of fry had been fair in spite of invasion of the pond by adult sunfish. On June 10, this pond was one of the three ponds in the entire H series (21 ponds) which had a turbidity of more than 7 parts per million.

Pond C-3 (0.71 acre) was stocked with 18,000 largemouth black bass fry on May 14 and treated with nigrosine at the rate of 10 pounds per acre on May 20. By June 10, much of the nigrosine had apparently been absorbed by the Chara in the pond. This plant covered most of the pond bottom but was only a few inches in height. Nigrosine was added at the rate of 25 pounds to the acre on June 10 and at the rate of 10 pounds to the acre on June 23. The Chara decomposed, and at one time the odor of hydrogen sulfide was noticeable about the pond. A noticeable waterbloom did not develop in this pond, and some Chara reappeared about the end of the operating season. The pond was drained on August 4, when an estimated 30 percent of the pond bottom was covered with Chara. The pond produced largemouth bass at the rate of 7,689 fingerlings or 74 pounds

[1] A black aniline dye, 128 B concentrated crystals, as sold by the National Aniline Division, Allied Chemical and Dye Corporation, Philadelphia, Pa.

Since the preparation of this paper, Mr. Surber has accepted a position with the U. S. Public Health Service. From headquarters in Chicago, Mr. Surber will work on pollution problems.--The EDITORS.

FIGURE 1.--Plankton net, bottom sampler, and 20-liter can used for collecting samples.

to the acre during an 83-day operating season. The largemouth bass control pond, H-16, produced 3,728 bass per acre; but the average for several years is somewhat higher (4,080). Evidently nigrosine was not biologically harmful in this pond.

Effects on Bottom Animals and Plankton

Ponds C-8 (0.33 acre), C-9 (0.25 acre), and C-10 (0.38 acre), already containing considerable vegetation (mostly Chara, Naias flexilis, Potamogeton crispus, and P. foliosus), received 10 pounds of nigrosine per acre on August 8, August 15, August 22, and August 29. The distribution of submersed vegetation in these ponds was charted.

Each of these ponds had been stocked with adult bluegills, and they and their young were always in evidence on the days of treatment and collection of samples.

Expansion of the weed beds was arrested by the addition of dye, and in some areas there was noticeable disintegration, particularly in beds of Naias flexilis. In general, however, the growth of plants continued to a moderate degree in spite of the nigrosine.

Plankton samples were collected from a canoe. A composite sample of pond water was dipped up in a 10-quart pail that could be cast for some distance and at various depths with a 10-foot sash cord. Individual samples were placed in a 50-quart tub, and from this two 20-liter samples--measured in a special can with glass gauge (figure 1)--were taken.

Bottom material was collected with an Ekman 6 by 6 dredge and put through a No. 30 soil sieve. Five bottom samples were taken from each pond on each of the treatment dates.

The zooplankton in these ponds (table 1) was poor, as is usually the case at the season when these experiments were conducted. Total numbers of zooplankton organisms, mostly rotifers, decreased in two of the three ponds.

Chironomid larvae, most important as fish-food animals, were most abundant in the bottom samples (table 1), showing an increase in the average number per square foot in two of the three ponds. Except in Pond C-9, where chironomid larvae were initially abundant, the data indicate no harmful effects. In two of the three ponds, bottom animals were more abundant near the end of the experimental period.

Effects on Pond Temperatures

On August 12, Pond H-21 was treated with nigrosine at the rate of 10 pounds to the acre. Similar applications were made on August 19 and August 26 for the purpose of observing the effects upon Cladophora glomerata--a coarse, densely growing filamentous pond-scum alga which was increasing in abundance in this pond--and upon water temperatures.

Pond H-21 has a surface area of 0.68 acre, a volume of 622,040 gallons, and an average depth of 2.8 feet. Adjacent to Pond H-21 is Pond H-20, which has a surface area of 0.63 acre, a volume of 656,570 gallons, and an average depth of 3.2 feet.

On August 19, recording thermometers were placed opposite each other in these ponds at points midway of each pond. The bulbs were placed halfway between surface and bottom at a depth of 1.5 feet. Temperatures in the treated pond, H-21, were compared with temperatures recorded for Pond H-20 at 6:00 a.m., noon, and 6:00 p.m., from August 20 through August 29. A maximum difference of 3° F. occurred

TABLE 1.--Effects of 10-pound per acre applications of nigrosine on plankton and bottom animals in ponds

Organism	Pond C-8				Pond C-9				Pond C-10			
	Aug. 8	Aug. 15	Aug. 22	Aug. 29	Aug. 8	Aug. 15	Aug. 22	Aug. 29	Aug. 8	Aug. 15	Aug. 22	Aug. 29
Cyclops	-	-	1	-	3	-	-	-	-	-	-	-
Diaptomus	-	-	-	-	-	-	-	-	-	-	-	-
Nauplii	1	1	2	1	7	-	-	-	-	-	-	1
Ceriodaphnia	-	-	-	-	-	-	-	-	-	-	-	-
Scapholeberis	-	-	-	-	-	-	-	-	-	-	-	-
Chydorus	-	-	-	-	-	-	-	-	-	-	-	-
Alona	1	-	3	-	-	-	-	-	-	-	-	-
Ostracods	4	-	-	-	3	-	2	-	3	1	-	1
Polyarthra	57	159	18	18	25	93	4	2	-	8	4	7
Monostyla	17	21	6	-	9	1	6	2	9	5	3	1
Anuraea	-	1	-	-	2	6	1	2	-	-	-	-
Miscellaneous	2	3	3	4	5	7	2	1	1	1	4	6
Total per liter	82	185	33	23	54	107	15	7	13	15	11	16
					(Average number per square foot)							
Oligochaeta	-	-	19	18	44	246	10	20	28	10	14	12
Caenis nymphs	3	6	5	13	3	22	14	16	3	2	9	6
Haliphid beetle larvae	1	-	-	9	3	4	2	8	-	6	-	4
Berosus beetle larvae	6	4	8	9	19	58	14	8	4	9	2	6
Chironomid larvae	130	86	229	334	610	302	298	308	218	164	273	254
Chironomid pupae	7	3	10	22	26	10	22	15	3	11	6	11
Pisidium	46	35	11	21	13	51	2	2	-	-	5	2
Physa	3	4	2	5	7	13	34	-	4	1	-	3
Leeches	-	2	1	2	-	1	2	3	2	1	-	2
Miscellaneous	2	-	2	1	1	2	2	2	9	-	2	-
Total	198	140	287	434	726	709	400	382	271	204	309	300
Average wet weight (grams per square foot)	0.592	1.364	1.096	0.816	1.977	1.624	1.444	1.198	0.585	0.334	0.785	0.373

FIGURE 2.--Illuminated bench used to keep plants alive during nigrosine experiments.

within 1 to 3 days after nigrosine was applied. The maxima followed closely the applications on August 19 and 26. The minimum difference was 0.5° F.

It was concluded that 10 pounds of nigrosine per acre caused the water to warm slightly but, in these relatively shallow ponds, not to a harmful degree. Eicher (1947: footnote) observed a cooling effect in deep ponds.

LABORATORY EXPERIMENTS

It had been noted that nigrosine soon disappeared from ponds that contained much coarse submersed vegetation. To determine whether the aquatic plants absorbed the dye, an experiment was set up in laboratory aquaria, each of which contained 20 liters of water.

Seven aquaria received nigrosine at the rate of 20 pounds per acre (2.4 parts per million). In this series, the control received no vegetation, two aquaria received 60 grams of common waterweeds (Anacharis canadensis), two received 120 grams, and two received 240 grams of fresh plants from which the surplus water had been drained.

For five aquaria, the rate of treatment was 10 pounds per acre (1.2 parts per million based upon a 10-pound treatment to an acre 3 feet deep). One aquarium was not stocked with plants, two aquaria received 60 grams of Anacharis, and the other two received 120 grams each.

Each aquarium was stocked with five bluegills about 2 inches long.

Changes in the nigrosine content of the water were determined by light transmittancy tests in a photolometer after standards representing amounts ranging from 0 to 2.4 parts per million of nigrosine had been prepared. The various degrees of transmittancy recorded for the standards were used in the preparation of an analytical curve. A red filter, Cenco No. 87309C, was used. Readings within 0.03 milligram of nigrosine per liter were recorded. The temperature and the nigrosine content of the water were observed daily.

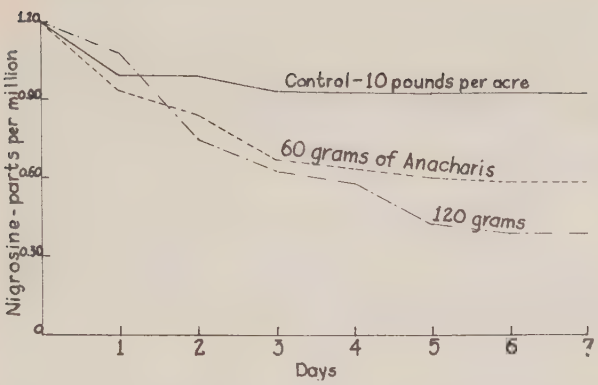
As it was desired to have the plants in these experiments live, fluorescent lights with white bulbs (figure 2) were placed over the aquaria for illumination at night. With this illumination, plants and fish in the aquaria survived.

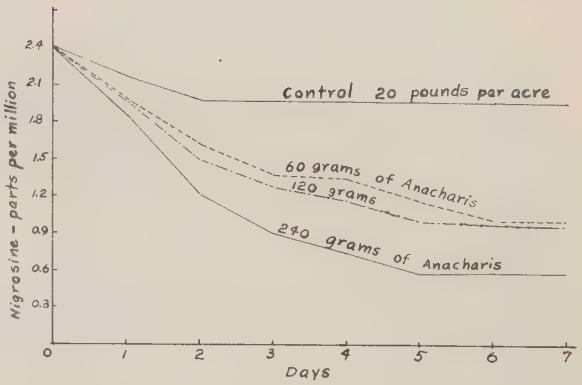
Nigrosine was taken up by the plants in some manner. The rate of removal and the total amount removed were proportional to the amount of weeds, as illustrated by figures 3 and 4. After 7 days, in the aquaria stocked with 60 grams of weeds and treated with nigrosine at a 10-pound per acre rate, the nigrosine content was equal to 53 percent of the amount in the aquaria that received twice as much nigrosine. After 7 days, in aquaria stocked with 120 grams of weeds and treated with the same amount of nigrosine, the nigrosine content was equal to 40 percent of the amount in aquaria containing only 60 grams of weeds. The control aquarium contained 77.5 percent of the original amount of nigrosine.

At the end of 7 days, the control aquarium that received 20 pounds of nigrosine per acre contained 82.5 percent of the original amount. At the same time, the aquaria that had received 60, 120, and 240 grams of Anacharis, respectively, contained 46, 41, and 25 percent, respectively, of the original nigrosine.

Effects on Daphnia

Twenty liters of pond water and 100 adult Daphnia magna were put into each of 10 aquaria. The Daphnia magna had been





FIGURES 3 and 4.--Effects of quantity of vegetation on nigrosine content of water.

obtained from a swarm in a hatchery pond; the pond water had been strained through No. 20 silk bolting cloth. Two aquaria served as controls; two each of the remaining aquaria were treated at the rate of 10, 20, 30, and 60 pounds of nigrosine per acre, or 1.2, 2.4, 3.6, and 7.2 milligrams per liter, respectively.

After exposure for 5 days, the water in the aquaria was strained and the organisms and their young were recaptured and counted. The results of this experiment are summarized in table 2.

Only two aquaria, both treated at 20 pounds per acre, showed a serious reduction in the numbers of Daphnia magna. As the species survived well at 30 and 60 pounds of nigrosine per acre, it is believed that the organisms in these aquaria suffered from unknown factors and that nigrosine was not directly harmful to this entomostracan.

Some young Daphnia were liberated from the brood chambers of adults during the experiment, causing a slight increase in the numbers in several aquaria.

TABLE 2.--Results of the exposure of Daphnia magna to different concentrations of nigrosine over a 5-day period

	Nigrosine parts per million	Initial number of daphnia	Number present after 5 days	Average number per treatment	Remarks
Control	-	100	114		Parthenogenic eggs in most individuals. No ephippial eggs.
Control	-	100	96	105	Parthenogenic eggs in most individuals. No ephippial eggs.
10 pounds/acre	1.2	100	149		Most individuals have parthenogenic eggs.
10 pounds/acre	1.2	100	101	125	Most individuals lack parthenogenic eggs. No ephippial eggs.
20 pounds/acre	2.4	100	10		Catastrophe, possibly due to contamination.
20 pounds/acre	2.4	100	49	30	Mostly large individuals left; some have parthenogenic eggs.
30 pounds/acre	3.6	100	88		Some individuals have parthenogenic eggs.
30 pounds/acre	3.6	100	122	105	Both adult and young individuals present.
60 pounds/acre	7.2	100	67		Many individuals have a few parthenogenic eggs.
60 pounds/acre	7.2	100	110	89	Both adult and young present. Parthenogenic eggs in most large individuals.

SUMMARY AND CONCLUSIONS

Two bass nursery ponds treated with nigrosine early in the season produced good yields of fish. One pond developed a waterbloom after two treatments of nigrosine at 10 pounds per acre. In the second pond, three applications of nigrosine at 10, 25, and 10 pounds per acre, respectively, were required to bring a young growth of Chara under control. No waterbloom developed in this pond, the water of which remained black for a long period.

Evidence from pond and aquarium experiments indicates no harmful effects on sunfish and bass at concentrations of the dye required to control weeds.

In three ponds that contained considerable vegetation, consecutive 10-pound per acre applications of nigrosine arrested growth of the plants but did not cause their destruction. Laboratory experiments showed that the dye was removed by the plants, the rate of removal being proportional to the amount of plant material present. As in the ponds, only about 1 week was required to remove most of the dye provided in a 10-pound per acre application where vegetation was abundant.

In these ponds, the effect upon the abundance of zooplankton organisms and bottom animals was determined by quantitative methods. There were few zooplankton organisms in the midsummer samples. In two out of three ponds, the most abundant rotifer declined in numbers after the second application but bottom animals increased in average number per square foot.

Recording thermometers in two adjacent bass nursery ponds showed that during daylight hours the water temperatures halfway between surface and bottom were increased as much as 3° F. when the treatment rate was 10 pounds per acre.

Laboratory experiments showed that Daphnia magna could well survive the dye at concentrations up to 7.2 parts per million (60 pounds per acre 3 feet deep) over a 5-day period.

The development of waterbloom algae in a hard-water pond to which nigrosine was added early in the season, affords promise of a means of encouraging the development of these forms over coarse weeds.

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Slow-moving species like the carp and sucker are more frequent items in the cormorant diet than bass, bluegill, trout, and salmon. Except for the occasional raiders of commercial nets and the individuals attracted by fish hatcheries, cormorants ordinarily eat rough fish such as sculpin, gunnel, sand launce, and capelin.

TOXICITY OF SOME NEW INSECTICIDES TO SEVERAL SPECIES OF PONDFISH

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WITHIN the last 10 years, a number of new chemicals for controlling some of the more important insect pests have been placed on the market. Since 1946 the Alabama Agricultural Experiment Station at Auburn, Alabama, has been conducting experiments to determine the toxicity and effects of some of the more important of these insecticides on pondfish. Though far from complete, available data are presented to give the fishery worker a rough guide to toxicity of the more common insecticides. The chemicals tested were DDT (dichloro-diphenyl-trichloroethane), methoxychlor (dimethoxy-diphenyl-trichloroethane), toxaphene (chlorinated camphene), chlordane, and BHC (benzene hexachloride or hexachloro-cyclohexane).

Effects of DDT

During World War II, DDT was widely used by the Allied Forces to control mosquitoes and other insect pests in occupied countries. By the end of the war, this material had become widely publicized in the United States, and, as sufficient quantities of the material became available, its use for insect control spread rapidly.

During the last 10 years, a vast amount of data has been obtained concerning the toxicity of DDT to both warm- and cold-blooded animals. As a result of this work, DDT is not used so promiscuously today as it once was. Especially should the fish-culturist or pond owner be careful in the use of this material around ponds, as it is toxic to fish even at low concentrations.

In aquarium tests conducted by the U. S. Fish and Wildlife Service (Surber 1948), DDT in a fuel-oil formula killed bluegills (Lepomis macrochirus) at a concentration of 0.14 p.p.m., whereas wettable powder at the same rate did not kill this species. Bluegills in concrete pools were killed by DDT in a fuel-oil formula at a concentration of 0.04 p.p.m. In these same pools but in cooler weather, largemouth black bass (Micropterus salmoides) and golden shiners (Notemigonus crysoleucas auratus) withstood a DDT concentration of 0.18 p.p.m., while bluegills and black crappie (Pomoxis nigromaculatus) were killed. In these pool experiments, the condition of the fish made a difference in their susceptibility to DDT. The better fed the fish, the higher concentration of DDT they could withstand. It was also found that the fry of largemouth black bass and black crappie were killed at lower concentrations than were fingerlings and adults of the same species.

Experiments on toxicity of DDT to fish have been conducted by the Alabama Agricultural Experiment Station in aquaria and in earthen ponds. In a quarter-acre earthen pond, the population of golden shiners (total length, 4 to 5 inches) was

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See also:

Hoffmann, C. H., and Surber, E. W. 1949. Effects of an aerial application of DDT on fish and fish-food organisms in two Pennsylvania watersheds. Prog. Fish-Cult. 11 (4): 203-211.

not completely killed by 1.75 p.p.m. of DDT (50 percent wettable powder) applied in three applications during a 30-day period. This amounted to 4.7 pounds of the technical DDT per acre-foot of water. When the pond was drained in the fall to recover the golden shiners, it was flushed with two partial fillings of water before being refilled and restocked with bluegills (total length, 3 to 4 inches) for the next experiment. Despite these precautions, approximately 94 percent of the bluegills stocked in the pond were killed by the DDT retained in the pond bottom.

Adults of bluegill bream, largemouth black bass, and buffalo (Megastomatobus cyprinella) in an earthen pond were not killed by a 1 p.p.m. concentration of DDT in the form of wettable powder. Forty-five days later the same pond received a 0.2 p.p.m. treatment of methoxychlor, an analog of DDT that is becoming widely used for insect control work. This compound killed all the bluegills and largemouth black bass, but the buffalo were still alive when the pond was drained 15 days later.

Five earthen ponds stocked with adult (total length, 5 to 6 inches) and fingerling (total length, 2 to 3 inches) bluegills and yearling (total length, 6 to 8 inches) largemouth black bass, received emulsified DDT in concentrations of 0.01, 0.05, 0.1, 0.2, and 0.5 p.p.m. Observations and counts on mortality were made each day from the time the DDT was added until the fish stopped dying. In addition, to determine how long the water remained toxic, cages of live fish were placed in each pond 4 days after the poison was applied. These cages were observed each day; the dead fish were counted, and replacements with live fish were made. The ponds were drained 7 weeks after the DDT was added, and the live fish were counted.

Some mortality among fingerling bluegills was observed in the pond containing DDT at the rate of 0.01 p.p.m., but none of the large bluegills seemed to be affected. At this concentration there was no mortality among largemouth black bass, top minnows, or tadpoles. The cage tests indicated that the 0.01 p.p.m. concentration of DDT was no longer toxic to bluegills by the end of 21 days. When the pond was drained, all the adult bluegills and yearling bass that had been stocked were recovered. Some fingerling and recently hatched bluegills were also recovered. It is believed, however, that some mortality of the fingerling bluegills in this pond was due to bass predation.

Large bluegills were not observed to be affected by the 0.05 p.p.m. concentration of DDT, but a considerable number of the fingerling bluegills in this pond were killed within 72 hours. Several of the bass were also seen dying during this period. Cage tests indicated that DDT at this concentration was no longer toxic to fingerling bluegills 21 days after its application. When the pond was drained, all the adult bluegills stocked were recovered, but only one of the six bass remained alive. There were few fingerlings and no recently hatched bluegills in the pond at that time.

All the fingerling bluegills and yearling bass were killed in the pond that received DDT at the rate of 0.1 p.p.m. Adult bluegills were able to survive this concentration. The cage tests indicated that this DDT concentration was no longer toxic to bluegills 30 days after it was applied. When the pond was drained, the large bluegills were the only fish recovered.

Adult bluegills were not killed in the pond that received the 0.2 p.p.m. concentration of DDT, but all the fingerling bluegills and yearling bass were killed. The cage tests were not conducted for a sufficient length of time to determine how long this DDT concentration remained toxic to bluegills in this pond.

All bluegills and bass were killed in the pond that received the 0.5 p.p.m. concentration of DDT. When the pond was drained 7 weeks later, the water was still toxic to fingerling bluegills; however, there were large numbers of top minnows alive in the pond at that time. These top minnows undoubtedly came into the pond from the water supply sometime after the DDT was added, as it was noted that the top minnows were killed within 72 hours after the pond was treated.

These results indicate that emulsifiable DDT in concentrations greater than 0.01 p.p.m. is toxic to adult largemouth

black bass, and, in concentrations greater than 0.1 p.p.m., it is toxic to large bluegills. Apparently concentrations greater than 0.01 p.p.m. were toxic to small bluegills, but, because of insufficient data, definite conclusions cannot be drawn. The length of time that DDT remained toxic in concentrations of 0.1 p.p.m. or less was 1 month. The length of time it remained toxic in concentrations greater than 0.1 p.p.m. was not determined.

Two bait-minnow species, fatheads (Pimephales promelas) and goldfish (Carassius auratus), were killed by DDT. In one earthen pond stocked with both species, a 0.4 p.p.m. concentration of DDT (wettable powder) killed only the recently hatched fathead minnows. Seining one week later revealed that the large fatheads and goldfish were still alive. That same day 1.6 p.p.m. DDT (wettable powder) was added, making the total concentration of DDT in this pond equal to 2 p.p.m. This concentration killed all fish present within 48 hours. Seining 1 month later, however, revealed the presence of recently hatched goldfish. The goldfish eggs had apparently been laid prior to the last poisoning and had hatched after the toxicity of the DDT had somewhat dissipated. When the pond was drained approximately 2 months after the second application of DDT, the young goldfish were still alive; however, there were no adult fish in the pond at that time.

All goldfish in another earthen pond were killed by emulsifiable DDT in a concentration of 0.1 p.p.m.

In aquaria, bluegill fingerlings (total length, 2 to 3 inches) were killed by DDT in a concentration of 0.15 p.p.m.; largemouth black bass fingerlings (total length, 3 to 4 inches) were killed by a 0.05 p.p.m. concentration, and bait-size goldfish (total length, 3 to 4 inches) were killed by DDT (50 percent wettable powder) in a 0.2 p.p.m. concentration.

Normal field dusting employs DDT dust in combination with other insecticides, and the rate per application for control of cotton insects is 0.5 pound of technical DDT per acre. If dusted at an equivalent rate over a 1-acre pond having an average depth of 5 feet, the concentration of DDT would be 0.04 p.p.m. According to the results of the experiments, this amount would not be toxic to fish, provided that there was no difference in the toxicity of wettable powder and dust. If repeated applications of the dust fall on the pond, however, or are carried into the pond by run-off water from the watershed, there is likely to be a serious mortality of fish. This mortality may persist for several months. There is urgent need for additional information concerning the length of time DDT will remain toxic in impounded waters.

Effects of Toxaphene

Though the use of toxaphene is rather recent, its effectiveness in control of the boll weevil is already well known. Throughout the Cotton-Belt States, the use of toxaphene has increased rapidly since its introduction in 1946. During the summer of 1949, millions of pounds of this material were dusted over cotton fields. Numerous reports of fish dying in ponds after the application of toxaphene to adjoining cotton fields were heard over the southeastern States during that summer.

Considerable research has been done to determine the toxicity of toxaphene to fish. Surber (1948) reported that bluegill bream and golden shiners were killed at a concentration of 0.02 p.p.m. of toxaphene (field formulation, 12 percent solutions in naphthenic solvent and fuel oil). Largemouth black bass were killed by a 0.04 p.p.m. concentration of the same toxaphene preparation.

As cotton is dusted with a 20-percent toxaphene dust, the experiments at Auburn were designed to determine the toxicity of this dust to pondfish. In aquaria, bluegill and largemouth bass fingerlings were killed in 36 hours by a 0.05 p.p.m. concentration of toxaphene. At this same concentration, goldfish were killed in 156 hours: in the last 105 hours, the goldfish were inactive, lying on their sides and barely moving their gill flaps or fins. In a small earthen pond, a 0.05 p.p.m. concentration of toxaphene did not kill bluegill fingerlings, bass fingerlings, and bait-size goldfish within a 5-week period.

The dusting procedure recommended for cotton consists of 6 to 8 applications of toxaphene during the boll-weevil infestation period. Each acre of cotton receives 10 pounds of 20-percent toxaphene dust per application. Because this is a very fine dust and is applied either by airplane or by power dusters, there is usually a considerable drift of dust onto areas adjoining that being dusted. If one regular field application of toxaphene were applied to an average 1-acre pond, it would result in approximately 0.2 p.p.m. of toxaphene in the pond water. This concentration (0.2 p.p.m.) of toxaphene was added to a small earthen pond containing bluegill and bass fingerlings and bait-size goldfish. All fish were dead within 45 hours. Five weeks later this pond was restocked with bluegill fingerlings. A majority of these fish survived for 3 weeks, but all were dead at the end of 6 weeks. The water in this pond was toxic for 10 weeks; the water will be checked to see how many weeks it remains sufficiently toxic to kill fish.

Sufficient data are now available to indicate that large-scale dusting with toxaphene can be harmful to fish life in impounded waters. Additional work is needed to determine: first, how long toxaphene in pond waters remains toxic to fish; second, whether run-off water from a toxaphene-dusted area dissolves or transports an appreciable amount of toxaphene.

Effects of Chlordane

Chlordane is often used for control of grasshoppers, boll weevils, and fire ants, as well as for control of household insects. The normal field application for boll-weevil control is 0.1 pound of chlordane per acre. In an average 1-acre pond, this would result in a chlordane concentration of approximately 0.09 p.p.m. To the author's knowledge, the Cotton Belt has had no reports of fish mortality believed to have been caused by chlordane.

Surber (1948) reported that, in pond experiments, chlordane applied at the rate of 1 pound per acre killed 87 percent of the bluegill bream. He did not state the p.p.m. concentration of chlordane in the pond water. In his aquarium test, a field formulation of chlordane (12 percent solutions in naphthenic solvent and fuel oil) at 0.04 p.p.m. failed to kill fish.

In aquarium tests conducted at the Alabama Station, bluegills, largemouth black bass, and goldfish were not killed by chlordane at a concentration of 0.1 p.p.m. At a 0.2 p.p.m. concentration, largemouth black bass were killed in 30 hours and bluegill bream in 87 hours; goldfish were not killed at this concentration of chlordane.

In another experiment, bluegill fingerlings and goldfish survived chlordane at a concentration of 0.2 p.p.m. in an earthen pond at Auburn, but largemouth black bass fingerlings were killed.

There is less available information on the toxicity of chlordane to fish than there is about DDT and toxaphene.

Effects of BHC

Research results have shown that the gamma isomer of benzene hexachloride is more toxic than the beta and delta isomers to boll weevils and other field insects. Laboratory tests by Surber (1948) showed that 0.05 p.p.m. of gamma isomer field formulation of BHC (12 percent solutions in naphthenic solvent and fuel oil) was toxic to all species of fish tested. The beta isomer in a similar field formulation at a concentration of 0.5 p.p.m. killed no fish. The delta isomer, also in a field formulation, produced toxicity symptoms at 0.2 and 0.5 p.p.m. concentrations of BHC, but all fish recovered. In an earthen pond, a field formulation of BHC gamma isomer at a concentration of 0.18 p.p.m. failed to kill bluegills, goldfish, golden shiners, and several species of minnows. In an aquarium test, inch-long bluegills were not killed by a 0.45 p.p.m. concentration of BHC gamma isomer.

Aquarium tests conducted at the Alabama Station with gamma isomer of BHC revealed that 50 percent of the bluegill fingerlings (total length, 2 to 4 inches) and largemouth black bass fingerlings (total

length, 3 to 4 inches) were killed by a 0.1 p.p.m. concentration, but the goldfish (total length, 3 to 4 inches) were not affected. At a 0.2 p.p.m. concentration, bluegills and largemouth black bass were killed, but goldfish survived.

For effective cotton-insect control, it has been recommended that the BHC dust be mixed with DDT. This mixture contains 3 percent gamma isomer BHC plus 5 percent DDT. A normal field application on a 1-acre pond (average depth, 5 feet) would give approximately 0.03 p.p.m. BHC and 0.05 p.p.m. DDT concentration.

This standard dusting mixture was tested in aquaria at Auburn. At a concentration of 0.03 p.p.m. of BHC plus 0.05 p.p.m. of DDT, bluegills (total length, 2 to 4 inches), largemouth black bass (total length, 3 to 4 inches), and goldfish (total length, 3 to 4 inches) survived. At a concentration of 0.1 p.p.m. of BHC plus 0.1 p.p.m. of DDT, largemouth black bass were killed but bluegills survived. A concentration of 0.1 p.p.m. of BHC plus 0.16 p.p.m. of DDT killed both bluegills and largemouth black bass. This last concentration would correspond to a triple standard field application for cotton-insect control.

Summary

Experiments were conducted to determine the toxic concentrations of the commercial insecticides DDT, methoxychlor, toxaphene, chlordane, and BHC to common pondfish in aquaria and in earthen ponds. In the aquarium tests, toxaphene at a concentration of 0.05 p.p.m. killed 100 percent of bluegill and largemouth black bass fingerlings; DDT at a concentration of 0.05 p.p.m. killed all bass fingerlings, and at 0.15 p.p.m. it killed 100 percent of the bluegill fingerlings; methoxychlor at 0.2 p.p.m. killed large bluegills and bass; chlordane at a concentration of

SUMMARY OF TOXIC CONCENTRATIONS OF INSECTICIDES TESTED FOR SEVERAL SPECIES OF FISH

Species	DDT		Methoxychlor	Toxaphene	Chlordane	BHC
	50% wettable powder (p.p.m.)	Emulsified (p.p.m.)	dust (p.p.m.)	dust (p.p.m.)	dust (p.p.m.)	gamma isomer dust (p.p.m.)
Bluegills						
large fingerling	- / [b]0.15	[a]0.1 / [a]0.01+	[bc]0.2 / -	- / [b]0.05 - [a]0.2	- / [b]0.2	[b]0.1 - 0.2
Bass						
large fingerling	- / [b]0.05	[a]0.01+ / 0.01	[bc]0.2 / -	- / [b]0.05 - [a]0.2	- / [ab]0.2	[b]0.1 - 0.2
Goldfish	[b]0.2 - [a]1.6	[a]0.1	-	[b]0.05 - [a]0.2	-	-
Fatheads						
adult	[ad]1.6	-	-	-	-	-
small	[a]0.4	-	-	-	-	-
Top minnows	-	[a]0.5	-	-	-	-

[a] Earthen pond. [b] Aquarium. [c] Added 45 days after application of 1 p.p.m. wettable DDT. [d] Added, same day, to water that had received 0.4 p.p.m.

0.2 p.p.m. killed 100 percent of the bluegill and bass fingerlings; BHC at a concentration of 0.1 p.p.m. killed 50 percent of the bluegill and bass fingerlings; 0.1 p.p.m. of BHC plus 0.1 p.p.m. of DDT killed bass fingerlings, but bluegills survived; 0.1 p.p.m. of BHC plus 0.16 p.p.m. of DDT killed all bluegills and bass. In earthen ponds, toxaphene at a concentration of 0.2 p.p.m. killed bluegills and bass; emulsifiable DDT at a concentration of 0.01+ p.p.m. killed fingerling bluegills and yearling bass, and at a concentration of 0.1 p.p.m. it killed adult bluegills; and chlordane at 0.2 p.p.m. killed bass fingerlings.

Two species of bait minnows, goldfish and fatheads, were also tested. In aquaria, goldfish were killed by toxaphene at a concentration of 0.05 p.p.m. and by DDT wettable powder at 0.2 p.p.m. In earthen ponds, goldfish were killed by toxaphene at 0.2 p.p.m., by DDT wettable powder at 1.6 p.p.m., and by emulsifiable DDT at 0.1 p.p.m. The fatheads in earthen ponds were killed by DDT wettable powder at a concentration of 0.4 p.p.m.

In earthen ponds, DDT wettable powder remained toxic to bluegills for several months. Emulsifiable DDT at a concentration of 0.1 p.p.m. or less remained toxic to bluegill fingerlings for 1 month; at greater concentrations it remained toxic much longer. Toxaphene at a concentration of 0.2 p.p.m. remained toxic to bluegills for more than 10 weeks.

Literature Cited

Surber, E. W.
1948. Chemical control agents and their effects on fish. The Prog. Fish-Cult. 10 (3): 125-131.

For years, visitors to the Cortland (New York) Laboratory have gazed with awe upon one exhibit that is not pickled in alcohol. Strong men entering upon duty there for the first time have been known to quail before these relics, which hang just where their hard-worked owner left them. Nevertheless, when A. V. Tunison returned to the laboratory recently, he had so little reverence for these evidences of his toil that he donned the garments and posed for his picture.

SUMMARY OF FARM-POND INSPECTIONS, 1949

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IN ORDER to gain some idea of the success of the farm-pond program in Region Three of the Fish and Wildlife Service, 116 farm ponds were inspected by station superintendents during October and November 1949. The distribution of the ponds inspected was as follows:

North Dakota	--	20
South Dakota	--	40
Minnesota	--	2
Iowa	--	11
Illinois	--	17
Indiana	--	8
Ohio	--	8
Michigan	--	10

Standard inspection forms were filled out for each pond, and these forms were summarized in the Regional Office. The results are set forth in the tabulation.

Of the 116 ponds, 10 (9 in South Dakota and 1 in Minnesota) were completely dry. Drying was determined to have been caused by a combination of drouth and pervious soil. Next to winterkill, drying was the greatest single cause of complete pond failure. Because drying was a somewhat abnormal condition, however, these ponds were not considered in averaging the prevailing pond conditions. Averages were based upon 106 ponds that contained water.

Eighteen ponds were classed as complete failures; that is, no fish of any kind could be found. Failure of 11 ponds (all in North Dakota) was attributed to winterkill. Three unsuccessful ponds had heavy populations of salamanders. Two failures were acid bog ponds, apparently not suited to game fishes. Livestock had made one pond too turbid. Another pond showed unfavorable water conditions caused by lignite leaching.

Seventy-six (71.7 percent) of the ponds were classed as being out of balance, although the definition of the term "balance" seems to vary somewhat among observers. Aside from the ponds already listed as complete failures, a number of the ponds inspected showed unbalanced populations and adverse habitat conditions caused by various factors. Excessive bluegill populations occurred in 23 ponds, excessive bullhead populations appeared in 21 ponds, and excessive green sunfish populations existed in 3 ponds. Partial winterkill was considered responsible for one unbalanced pond. Adverse habitat conditions were caused by extreme turbidity, excessive shallow water, under fishing, no fishing, lack of fertilization, ill-advised stocking by pond owners, and, to a minor extent, excessive aquatic vegetation.

Sixty-one (57.5 percent) of the ponds were classed as being turbid. Uncontrolled access by livestock and wind action on shallow water were indicated as being the most important causes of turbidity. It is noteworthy that only five cases of well-developed water bloom were reported. It seems likely, however, that in many ponds the presence of a bloom was masked by inorganic turbidity. Excessive areas of water less than 18 inches

Extent

Listed on application	498 acres
In use at time of inspection	374 acres

Description of ponds

	Ponds	
	Number	(Percent)
Date of planting		
Prior to 1945	3	
1945	8	
1946	24	
1947	59	
1948	15	
1949	4	
Water		
Turbid	61	57.5
Clear	45	42.5
Water bloom (definite)	5	4.8
Fertilization (some degree indicated)	8	7.6
Vegetated area		
None	30	28.0
1 to 5 percent	21	20.0
6 to 10 percent	18	17.0
11 to 25 percent	16	15.0
26 to 50 percent	9	8.5
51 to 75 percent	9	8.5
76 to 100 percent	3	2.8
Bottom		
Gravel	1	0.9
Clay	25	23.6
Mud, mud-silt, or mud-clay	79	75.0
Peat	1	0.9
Miscellaneous species present		
Crappies	7	6.6
Green sunfish	5	4.7
Minnows	4	3.8
Bullheads	1/31	29.0

1/ Mostly South Dakota ponds.

in depth were found in many of the ponds.

Sixty-six percent of the pond owners indicated an average interest, and they were attempting (with varying degrees of effort) to harvest fish. Under-fishing was a constant factor. More than 31 percent of the owners showed no interest in their ponds, and these men made little or no attempt to harvest fish. Above-average interest was shown by 2.8 percent of the pond owners, who took particularly good care of their ponds. Only 7.6 per-

Achievement

	Ponds	
	Number	(Percent)
In balance	30	28.3
	(Percent)	
[2/] Ponds planted in 1945 or before	50	
1946	37	
1947	28	
1948	14	
Out of balance	76	71.7

	Ponds	
Cause	Number	(Percent)
Bluegills predominating	23	21.7
Bullheads predominating	21	19.8
Green sunfish predominating	3	2.8
Winterkill	1	0.9
Not indicated	10	9.4
Complete failure		
Winterkill	11	10.4
Lignite leaching	1	0.9
Salamanders	3	2.8
Acid bogs	2	1.9
Extreme turbidity	1	0.9

Pond Owners

	Pond owners	
	Number	(Percent)
Degree of interest shown		
Above average	3	2.8
Average: harvest indicated	70	66.0
Little or none: no harvest indicated	33	31.2
Species of fish desired		
Bass alone	10	
Bass and bluegills	51	
Bass, bluegills, and bullheads	9	
Bluegills and bullheads	2	
Bullheads alone	1	
Catfish alone	0	
None specified	33	

[2/] Four samples.

cent of the ponds had received any degree of fertilization.

Excessive aquatic vegetation was not a major factor, as 65 percent of the ponds had 10 percent or less of their area covered by vegetation. Thirty ponds were completely lacking in vegetation. The species that occurred most commonly were filamentous algae, Chara, and cattail.

The majority of the pond owners were interested in the standard largemouth bass-bluegill combination. In South

Dakota, considerable interest was shown in bullheads, in combination with bass or bluegills. Most of the South Dakota ponds planted to the bass-bullhead combination were completely out of balance, however, with bullheads dominating the population. In only a few of these ponds could any bass be found. It is evident that when the owner shows a primary interest in bullheads, only this species should be planted.

SONIC EXPERIMENTS FAIL TO DISTURB TROUT

Experimental work with four pieces of sound equipment, the frequencies ranging from 65 to 70,000 cycles per second, both with sine curve and with discontinuous wave or noise characteristics, has thus far failed to provide a means of guiding salmon fingerlings away from underwater diversions and water-turbine intakes. Under the direction of J. T. Barnaby of the North Pacific Fishery Investigations (Branch of Fishery Biology of the Fish and Wildlife Service), Clifford J. Burner supervised more than 100 planned tests with rainbow and brown trout at the U. S. Fish-Cultural (Leetown) Station at Kearneysville, West Virginia.

Tests were made in a 60- by 450-foot hatchery pond into which had been placed a mesh structure (100 by 3 by 3 feet) divided by sliding gates into 10 compartments. In a typical test, 100 rainbow (4 to 24 inches in length) and brown trout were put into each compartment and the transducer (previously adjusted to a given frequency) was turned on simultaneously with the lifting of the gates. After a given length of time, the gates were lowered, the transducer was stopped, and the fish in each compartment were counted to determine their distribution in the structure. Sound waves of low frequency produced no reaction after an initial "start." High-frequency sounds apparently caused no reaction. An underwater turbine--though it produced a sound intensity great enough to crush a man's eardrums if he put his head beneath the surface--apparently caused the fish in the nearest section of the compartment to "start" when the noise was turned on, but this reaction was only momentary.

RAINBOW BROOD-STOCK SELECTION AND OBSERVATIONS ON ITS APPLICATION TO FISHERY MANAGEMENT

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A PROGRAM for rearing rainbow trout at the State Game Department Hatchery located near Goldendale, Washington, was initiated on the premise that more eggs could be produced in the life span of trout maturing at 2 years of age rather than at 3 and 4 years, as is more common. Further, it was believed that by holding brood stock of early maturity, the number of brood stock could be rapidly increased should a critical need arise for additional spawn. Selection through several generations of three different strains of fish proved that early maturity could be obtained and that such brood stock was of definite value in obtaining an increased number of eggs in a relatively short time. In evaluating the effects of early maturity on trout liberated for creel purposes, however, several aspects that were observed tended to disprove the value of this type of selection for producing trout under a fishery-management program. Records show that average egg production through three spawning seasons was not large and that the fish produced by 2-year-old spawners were often inferior during certain stages of their life cycle.

Procedure

In April 1940, when the Goldendale hatchery was first put into operation, a group of fingerlings which had been reared for approximately 13 months from brood stock held at the Yakima hatchery were transferred to Goldendale for brood-stock purposes. In November of that year, some 5,330 from this lot were on hand. As it was impossible to determine the sex of these fish by external observation, the assumption that one-half of the group were females was agreed upon as a standard method of estimating the number of females in each group of 2-year-old brood stock at the beginning of each spawning season. The term "2-year-old spawners" is used for convenience, though actually the mature fish in many instances were only 22 or 23 months old. Brood-stock replacements were obtained from eggs spawned only from 2-year-old fish. No effort was made to select for any other characteristics. All brood stock that reached 4 years of age were planted, as facilities were limited and a young group of brood fish was desired so that rapid expansion could be obtained if needed. This would not be possible in a group of brood stock composed of, for example, 5- or 6-year-old fish from which offspring could not be counted on to mature for 3 or more years.

Development of Early Maturity

In addition to the Yakima strain of rainbow, two other groups were used for selection, each being designated according to the source of spawn. Eggs obtained from the Meader Trout Farm at Pocatello, Idaho, were designated as the Meader strain; and eggs obtained from Cape Cod,

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Massachusetts, started the Cape Cod group. In three generations of brood-stock selection, the percentage of Yakima fish maturing as 2-year-olds advanced from 4.7 to 84.3 percent. Fish of the Meader group started with only 68 (or 1.7 percent of 4,018) females spawning as 2-year-olds. In four generations this number was raised to 65.2 percent. Females from the Cape Cod group matured at the rate of 18.6 percent in the first generation. The following generation produced 1,455 (or 62.4 percent of an estimated 2,330) mature females at 2 years of age. Thus it was clearly demonstrated that early maturity could be obtained by selective breeding.

Egg Production

As might be anticipated, early maturity tended to retard growth to some extent and, as a result, average egg production was low. Females spawning for the first time as 2-year-olds produced between 600 and 900 eggs. Rainbow brood stock spawning for the first time at other stations have averaged from 1,500 to 2,000 eggs per fish, with occasional 3-year-old females producing 3,000 eggs. At Goldendale high fertility was generally obtained, the losses due to hatching being as low as 3.8 percent. The small eggs obtained from 2-year-old spawners, however, produced small fry which were slow to start growth and--from a fish-culturist's standpoint--were generally more difficult to handle. Such small fry would, in effect, lose almost a month of rearing in comparison with fry which had hatched from larger eggs. This characteristic is extremely important in hatcheries of comparatively low water temperatures and where fishery management requires legal-sized trout in 10 to 12 months.

Fingerlings Inferior in the Creel

In Washington, as elsewhere, stream management calls for the planting of legal-sized trout. In any truck load of these large fingerlings, the occurrence of occasional precocious males is not an uncommon observation. Trout reared from 2-year-old spawners, however, produce considerable numbers of precocious bucks, which cannot be considered as suitable for creels. Ripe fish, as we all know, are soft and generally not in prime physical condition.

In the management of rehabilitated lakes which have been cleared of undesirable fish and replanted to trout, a common procedure is to prohibit fishing for some 18 months. By such action, planted trout have an opportunity to reach larger size and are approximately 2 years of age at the opening of fishing seasons. Under such circumstances, the planting of trout reared from 2-year-old spawners has, owing to the presence of many mature fish, greatly reduced the favorable effect of an otherwise successful opening day.

In other lakes where a substantial carry-over of yearling fingerlings to a second fishing season has been observed, maturity at 2 years of age markedly reduces the value of the carry-over of large trout. Most fishermen, as we all know, are more excited over one large fish than over a creel of small fish.

Growth retarded as a result of early maturity has also been observed in waters where rapid growth rates are common. In Dibble Lake, Okanogan County, trout grow at the rate of 1 pound to 1½ pounds in a single year. Fish that matured early were distinctly smaller and inferior.

Conclusions

As a result of these observations, only rainbow trout which mature at 3 years of age are being selected for brood stock and more attention is being given to other desirable characteristics such as time of spawning, high individual egg production, good growth, high fertility, and general appearance.

A METHOD OF TRANSPORTING FINGERLING SHAD

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AS PART of an extensive research program now being conducted with shad at the Beaufort, North Carolina, Laboratory of the Fish and Wildlife Service, methods of transporting shad in various age and size groups are being investigated.

It must be pointed out that shad fry have been moved successfully in milk cans for very great distances. Stone (1874) transported 35,000 shad fry by rail from Castleton on the Hudson River to Tehama on the Sacramento River. This shipment was managed very painstakingly, for it was deemed necessary to give each can a change of water every 2 hours depending upon the availability of fresh water. Stone and his assistants conducted a very commendable shad movement, displaying great resourcefulness throughout the trip in acquiring fresh water and in holding the water at the desired temperatures. As a result of their success, the progeny of the fry that they introduced have established an extensive shad run in the Sacramento River and other Pacific Coast streams.

The work of Hollis (1948) and Leach (1925) indicates that fingerling shad are extremely delicate and susceptible to a high rate of mortality when handled. No evidence has been found to show that fingerling shad--unlike the fry--have ever been moved for any distance successfully.

Recently it became necessary that we have live shad at the Beaufort Laboratory for physiological and other studies being conducted by members of the staff and guest investigators. Fingerling shad (Alosa sapidissima) were available 300 miles away, at the U. S. Fish-Cultural Station at Orangeburg, South Carolina, where they had been reared originally for a juvenile tagging experiment.

Before the experiments got under way, a pond near the laboratory was placed in readiness to retain the young shad. The pond is 50 feet long and 35 feet wide and has a maximum of 2 feet of water on the lower side. Five tons of gravel were spread on the bottom. Fertilizer and Chlorella were added in an effort to condition the water and establish a food chain for the shad.

The following account describes the equipment and methods employed in the three shipments of fingerling shad from Orangeburg, South Carolina, to Beaufort, North Carolina. Every known precaution was taken with the first shipment, but it was unsuccessful. The second and third shipments were planned even more carefully and were highly successful.

EQUIPMENT

A wooden transporting tank was built at the Beaufort Laboratory. The plans used were those of a University of Washington Standard Transportation Tank. Constructed of juniper and marine plywood, the tank has these inside dimensions: length, 51-3/4 inches; breadth, 29-1/2 inches; depth, 30 inches.

The base of the tank extends beyond one end to serve as a base for the small gasoline engine that provides aeration. Water is pumped from the bottom of the tank into two pipes which extend along the sides above the water level. Throughout their lengths, the pipes are perforated to allow small streams of water to be pumped back into the tank from the top.

The tank was given two coats of thin white paint on the inside to protect the

plywood from the water and one coat of grey deck paint on the outside. When the paint was dry, the tank was filled with water for a period of seasoning.

TRANSPORTATION

Mr. Reginald E. Willis, a mechanic employed by the Fish and Wildlife Service, accompanied me on all three trips. Mr. C. E. Atkinson, Director of the Laboratory, accompanied us on the second trip.

Experiment 1

When the pond and tank were completed, the latter was placed on a 3/4-ton pick-up truck. The journey to Orangeburg, South Carolina, got under way on the morning of February 13, 1950.

When we arrived at the hatchery, we surveyed the small pond in which the shad were being held. Mr. James W. McPhail, the superintendent, did not know the exact number of shad, as they had not been seen for some time.

At 8 o'clock the next morning, we started draining the pond slowly. We went to the end opposite the spillway and sprinkled water on the surface to scare the shad toward the spillway.

Before the fish were seined, six tubs, each two-thirds full of water, were placed on the beach near the spillway. The first haul with the seine produced about 80 fish. Two men held the seine 8 to 10 inches below the surface so that we could see the shad and determine their size and approximate number. During this time, care was taken not to bring the fish completely out of the water. As soon as the net was lifted, a tub was floated under it and the fish were dumped in very quickly. A very few scales were seen in the tub after the first haul. The same procedure was followed with the second haul, when approximately 200 fish were seined. About 250 fish were caught in the third haul. This time we dipped the shad from the seine with a bucket. In the fourth and final haul, 100 shad were removed.

Immediately after each haul, a net was placed over the newly filled tub. The tub was then placed on a truck, taken to a point 100 yards distant, and set under a continuous stream of water. From the time the first tub was placed under the trough until the fish were loaded into the tank on the truck, 1-1/2 hours elapsed.

We decided to take approximately half of the fish to Beaufort on the first trip. This meant that the fish in one of the heavily loaded tubs and in one of the lightly loaded tubs would be taken. To get a count, the fish were dipped with a hand net from the tub to a bucket of water. The average dip, made very rapidly, contained three fish. Only 50 fish were dipped to a bucket, and these fish were immediately placed in the transporting tank. The total number of fish loaded was 376. The contents of the other two tubs were released in a concrete pool by placing the tubs in the water and letting the fish swim out. We planned to pick up all these fish three days later if the first trip was successful.

When the fish were loaded, the temperature of the water in the tank, which had been filled with 200 gallons from the hatchery fresh-water system, was 16.5° C.

At 11 o'clock in the morning of February 14, we left Orangeburg with the 376 fingerling shad.

The water sloshing from one end of the tank to the other made the truck difficult to handle and maneuver, and this may have been an adverse factor in the transfer of the shad.

Mortalities were first noticed at 12 o'clock noon (table 1). The water taken on at the Orangeburg Station was stained. It was impossible to determine the exact number of dead shad. Prior to this trip, we had not installed a trap door in the cover of the tank. To take the water temperature or see the bottom of the tank, it was necessary to remove the cover, which was secured by six wing nuts.

At 5 p.m., the temperature had risen to 19.5° C., a probable factor in the failure of this experiment. As it started to rain at this time, we put a tarpaulin over the back of the truck to protect the engine from drowning. It is possible

that the accumulation of fumes from the engine also contributed to our failure in this shipment.

Immediately after our arrival at Beaufort, the tank was drained enough for the bottom to be visible. All 376 shad were dead, lying on the bottom at the forward end.

TABLE 1.--Record of first shipment of fingerling shad

Time	Tank: Temperature (C.) of water	Tank: Pump operation	Remarks
a.m. 11:00	16.5°	Continuous	Left Orangeburg with 376 live fish. Fresh water.
12:00	17.0°	Continuous	30 to 50 dead.
p.m. 1:00	18.0°	Continuous	Mortality about the same.
3:00	19.0°	Continuous	Increase in mortality difficult to estimate.
5:00	19.5°	Continuous	Water thick and cloudy with mucus. Tarpaulin erected.
8:45	19.5°	Continuous	Arrived at Beaufort. All fish dead.

Modification of Transfer Methods

After the first trip had been made, many faults could be found with the equipment and methods. Even though fingerling shad were presumed to be difficult to handle, it was believed that the faults of the methods and equipment could be remedied so that the shad would at least have a better chance to survive the 300-mile journey.

In the first place, it was believed that the tremendous surge of water in the tank was seriously detrimental. Furthermore, there was a strong feeling that the continual operation of the pump produced a spray too strong for the fish to withstand. Then too, there was conceived the idea that perhaps shad could be transported better in sea water than in fresh water.

It was decided that we should transport the next load of shad in water of 1.018 specific gravity, as Leach stated that this was quite good for the holding of shad. It was calculated that 137.5 gallons of sea water from Beaufort Harbor to 62.5 gallons of fresh water would give a specific gravity of approximately 1.018. More than 137.5 gallons of sea water was carried to Orangeburg to allow for possible loss enroute.

After much thought had been given to the possible lethal factors, horizontal baffle boards were installed to prevent the surge of water. Two boards, each 11-1/4 inches wide, were fastened along the sidewalls of the tank, 1-1/2 inches below the surface of the water. A board 15 inches wide was placed in the center of the tank, 11 inches from the bottom. The tank was placed on the truck, filled, and given a test run. No water surge could be felt in the truck, and there was no splash over the top of the tank (from which the cover had been removed).

A trap door was installed in the cover so that the temperature and bottom could be checked more regularly. A small roof was constructed over the engine to eliminate the necessity of a tarpaulin and possible mortality from engine fumes. A tank of compressed oxygen with an adapter for two rubber hoses was placed on the truck.

Experiment 2

With the improvements noted, we arrived in Orangeburg and on the morning of February 17 prepared to remove half the shad that had been left in the concrete pool.

The transporting tank was drained to 137.5 gallons. The temperature of that water was 9.5° C. To that water was added 62.5 gallons of fresh water from the pool in which the shad were living. The temperature of this water was 12.5° C. The temperature of the water when mixed was 11° C., but it dropped later as the water became more thoroughly mixed by the pump.

Because this was a cold day, the temperature stayed down during the entire trip.

The shad were seined and then transferred from the seine to the tank by bucket rather than by dip net. One hundred and three shad were put in the tank, and 10 shad were put in each of two 10-gallon milk cans filled with fresh water. These two cans were being used to test various methods of transporting the shad. One milk can was placed in a larger container filled with ice, and both milk cans were supplied with a very small amount of oxygen.

As shown in table 2, the pump on the tank was operated only 10 minutes in every hour after the first 95 minutes of the trip. At the end of each 100 miles, the entire top of the tank was removed and one top baffle was taken out. By doing this, we could examine the fish swimming near the bottom of the tank. These fish appeared healthy during the entire trip.

Eight of the shad in the iced can died when the temperature dropped to 2° C., and the other two shad in that can died by the time the temperature reached 0.5° C. The only explanation that can be offered for the death of two fish in the second can is that they were subjected to too much oxygen.

Two inches of sea water had been added to the receiving pond to eliminate the necessity of putting the shad directly into fresh water. Fifteen gallons of water was bailed from the tank, and water from the pond was pumped gradually to the original surface mark in the tank to balance the salinity and temperatures and prevent possible shock. This was repeated three times, after which the temperature of the water in the tank was 10.5° C., the temperature of the pond water. Can No. 1 was given the same treatment. When the temperatures balanced, the shad were dipped in buckets from the tank to the pond. The fish swam off vigorously.

Experiment 3

Because the second trip had been so successful, it was decided that the third would be conducted in the same manner except for two changes in the cans filled with fresh water: oxygen would not be used for Can No. 1, and ice would not be used for Can No. 2.

On the morning of February 21, 139 shad, the remainder of the lot, were seined from the pool at Orangeburg and dipped with buckets into the tank and cans. Ten shad were put into each of the two cans, and 119 shad were put into the tank. The temperature of the sea water was 8.2° C., and the temperature of the pool water was 11.2° C. When the water was mixed in the tank, the temperature was 9.8° C. and its specific gravity (effected as in the second experiment) was 1.018. The temperature of the water in both cans was 10° C. Oxygen was started in Can No. 2.

As summarized in table 3, the same success with the tank was attained in the third experiment as in the second. The pump was operated at the same intervals, and the temperature remained fairly constant.

In Can No. 1 (no oxygen) and Can No. 2 (oxygen) the temperature rose considerably higher than in the tank. Possibly this accounts for the loss of one fish in Can No. 1, and possibly the combination of the high temperature and an oversupply of oxygen accounts for the loss of two fish in Can No. 2.

As the temperature of the pond water was 14° C. and that of the water in the cans was so close (No. 1, 14.8° C.; No. 2, 14° C.), the cans were tilted in the pond and the fish allowed to swim out. They swam away, apparently in good condition.

The temperature and salinity in the transporting tank were balanced with the pond water before the fish were transferred. Once in the pond, they appeared even more active than those transported in the second trip.

SUMMARY

Three hundred and seventy-six fingerling shad were transported a distance of 300 miles in a live tank filled with fresh water. The temperature ranged from 16.5° to 19.5° C. The surge of water

TABLE 2.--Record of second shipment of fingerling shad.

Time	Tank			Can No. 1			Can No. 2 (Iced)		
	Temperature (C.) of water	Pump operation	Remarks	Temperature (C.) of water	Oxygen	Remarks	Temperature (C.) of water	Oxygen	Remarks
a.m.									
9:10	11.0°	Continuous	Left Orangeburg with 103 live fish. Specific gravity of water, 1.018.	10.5°	On	10 live fish.	10.5°	On	Ice added. 10 live fish.
9:53	10.0°	Continuous	-	10.0°	On	All living.	2.0°	On	8 dead; 2 weak.
10:40	9.9°	Continuous	-	9.5°	On	All living; 3 on their backs.	1.0°	On	9 dead.
10:45	-	Off	-	-	-	-	-	-	-
11:15	9.9°	-	-	8.5°	On	All living.	0.5°	On	All dead. End of temperature recording.
11:50	9.9°	10 minutes	Top off for inspection. All living.	8.0°	Off	All living.	-	Off	-
p.m.									
12:45	9.5°	10 minutes	-	8.0°	-	1 dead.	-	-	-
1:50	9.5°	10 minutes	-	8.0°	-	1 dead; 1 weak.	-	-	-
3:05	9.2°	10 minutes	-	8.6°	-	1 dead; 1 weak.	-	-	-
4:20	9.0°	10 minutes	Top off for inspection. All living.	9.0°	On	2 dead.	-	-	-
5:00	-	-	-	-	Off	-	-	-	-
5:30	8.7°	10 minutes	-	8.3°	-	2 dead.	-	-	-
6:55	7.7°	10 minutes	Arrived at Beaufort. Top off and baffles out for unloading. All living.	7.2°	-	8 living; 2 dead.	1.0°	-	All dead.

TABLE 3.--Record of third shipment of fingerling shad

Time	Tank			Can No. 1			Can No. 2		
	Temperature (C.) of water	Pump operation	Remarks	Temperature (C.) of water	Oxygen	Remarks	Temperature (C.) of water	Oxygen	Remarks
a.m.									
8:55	9.8°	Continuous	Left Orangeburg with 119 live fish. Specific gravity of water, 1.018.	10.0°	Off	10 live fish. Fresh water.	10.0°	On	10 live fish. Fresh water.
9:34	9.0°	Off	-	9.8°	-	All living.	9.8°	On	All living.
10:17	9.5°	-	-	10.3°	-	All living.	10.3°	On	All living.
10:48	9.5°	10 minutes	-	11.1°	-	All living.	11.5°	On	All living.
11:30	9.5°	-	Cover off for inspection. All living.	12.0°	-	All living.	12.2°	On	All living.
p.m.									
12:14	9.9°	-	-	13.0°	-	All living.	12.5°	On	All living.
1:30	10.2°	10 minutes	-	14.5°	-	All living. Good condition.	14.8°	Off	Fish at top of can and moving spasmodically.
2:35	10.5°	10 minutes	-	15.5°	-	All living.	16.5°	-	Fish look better. All but 1 at bottom.
3:30	10.8°	10 minutes	Cover off for inspection. All living.	15.0°	-	1 fish on back at top.	16.5°	On	2 fish at bottom look very weak.
4:50	11.0°	10 minutes	-	15.8°	-	1 dead.	15.8°	On	2 dead.
6:05	11.0°	10 minutes	Arrived at Beaufort. Top off and baffles out for unloading. All living.	14.8°	-	1 dead.	14.0°	Off	2 dead.

in the tank was very great, and the aeration unit was allowed to run continuously. All the shad were dead at the bottom of the tank upon arrival at their destination.

On a second attempt, 123 shad were transported: 103 in the tank filled with water having a specific gravity of 1.018, 10 in a milk can of fresh water supplied with oxygen, and 10 in a milk can of fresh water packed in ice and supplied with oxygen. The tank was equipped with baffles, and the temperature range was from 7.7° to 11° C. Aeration was applied 10 minutes in every hour. The temperature in the can without ice ranged from 7.2° to 10.5° C. Eight of the fish in the iced can died when the temperature went down to 2° C. No shad were brought back alive in the iced can. Eight shad were transported alive in the can without ice, and 103 were transported alive in the tank.

On the third trip, 139 shad were transported: 119 in the tank and 10 in each milk can. The procedure used with the tank during the second trip was repeated, and the temperature ranged from 9° to 11° C. All 119 shad in the tank were alive when they arrived. The temperature in the two cans ranged from 9.8° to 16.5° C. The higher temperature seemed to affect the fish, as they did not appear to be nearly so vigorous as those in the tank. Furthermore, the smallest amount of oxygen that could be released into Can No. 2 made the fish appear unhealthy. It is believed that the splash in the milk cans produced sufficient oxygen. Two shad in the can supplied with oxygen (No. 2) died, and one shad in Can No. 1 died.

We think that factors which certainly contributed to the success of the second and third trips were the addition of the baffles and the decrease in time during which the pump was run. We also believe that shad remain more vigorous and are not so susceptible to mortality if transported in at least part sea water. We have not proved this, however. Further, it is likely that the cool days on which the second and third lots were transported were beneficial to the vitality of the shad by preventing high water temperatures.

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1925. Artificial propagation of shad. Report, U. S. Commissioner of Fisheries for fiscal year 1924, App. 8, pp. 459-486. (Doc. No. 981, issued July 15, 1925.)

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1874. Report on shad hatching operations. Report, U. S. Commissioner of Fish and Fisheries for 1872 and 1873, App. C, xviii, pp. 413-416.

The green rosettes of the waterchestnut look rather attractive at first in lakes and streams, but the plant soon crowds out all other vegetation and prevents the growth of microscopic fish foods.

Since the city of Hot Springs, New Mexico, has changed its name, mail for the Federal fish-cultural station below Elephant Butte Dam will hereafter be addressed to Truth or Consequences, New Mexico.

FORTY-EIGHT YEARS AGO--

It is a hard matter to advise just how many fish of each species should be returned to the pond, the natural inclination being to make it too many. One hundred of your yearling black bass and twice the number of bream and catfish is plenty for each acre of water, and too many, unless you are pretty persistent in catching them out, and not over that number of fry should be retained to come on for the coming year's supply.

--J. J. Stranahan, "Fish culture on the farm." Transactions of the 31st Annual Meeting of the American Fisheries Society, 1902.

PERFORATED ALUMINUM SCREENS FOR CIRCULAR POOLS

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Marlinton, West Virginia

DURING THE spring of 1948 we became concerned about the unaccountable losses of small brook and rainbow fingerlings from the 42 circular pools at our Marlinton Fish Hatchery. An investigation disclosed that a large percentage of these losses could be attributed to the faulty operation of the patent drain screens in use in all our circular pools.

This patent drain screen consisted of a galvanized metal cylinder, 6 inches in diameter and 30 inches in height, fitted with a crank and shaft arrangement running the length of the cylinder and connected to a metal plate at the bottom. The screen was placed around the 3-inch standpipe drain. By turning the crank, located on top of the cylinder, it was possible to regulate the size of the opening between the bottom of the cylinder and the plate to the size of fish occupying the pool. The bottom opening was intended to effect cleaning of the pool by siphoning the wastes into the screen, thence upward to the standpipe outlet.

Close examination of all these screens revealed that most of them were rusted or damaged to the extent that it was impossible to regulate the opening, despite the fact that they had been in use for less than 2 years. An additional drawback associated with this type of screen was the constant attention required during the fall, when leaves collected around the small opening at the bottom--eventually closing it and causing the pool to overflow. Another, and probably more serious, handicap lay in its operation by inexperienced hatchery personnel. All too often, during the drainage or cleaning of the pool or screen, small fingerlings were lost down the drain if the screens

Aluminum screen in place, the standpipe leaning against screen.

Screen and catwalk in place. Patent drain is near rear wheel of truck.

(Photos courtesy the authors)

were removed carelessly or adjusted improperly.

With this evidence in mind, it was concluded that new and simple-to-operate screens were a necessity. It was decided that a square, perforated, rustproof metal screen would best fit our needs. This would set conveniently into the 10-inch square recess at the center of each circular pool. Forty-two sheets of perforated aluminum, measuring 40 inches by 24 inches, were obtained. The sheets were 1/8 inch in thickness; the perforations were at 5/16-inch centers and of 3/16-inch diameter. Each sheet was creased and bent every 9-1/2 inches along the 40-inch side, forming a square screen 24 inches in height. The last bend was within approximately 1-1/2 inches of the edge, and this overlap was riveted to close and secure the screen. A tight fit was obtained in all pools without wedging, and no space was left between the outside of the screen and the 3-inch deep recess of the pool drain for waste to collect.

These screens have been in use since July 1948, and we are completely sold on them. Their sole disadvantage is the lack of a self-cleaning action, but the small amount of debris that does collect around the bottom is easily and readily brushed through the many perforations or over the top of the screen. Their obvious advantages are:

1. No loss of fish. The screens can be cleaned without removing; no mechanical malfunctions are possible.

2. Saving of labor. One laborer can clean our 42 screens in 1 hour each day; the task formerly required two men for a 1-hour period daily.

3. Less expense. One 24- by 40-inch perforated aluminum sheet costs $5.15, as against $11 for the patent drain type. No wooden frames are necessary.

4. Permanency. The screens are rustproof and are not handled often enough to damage.

5. Simplicity of operation. Inexperienced labor can be used without fear of accidents.

6. No clogging with debris.

Carp are non grata to duck hunters as well as to anglers for game fish. In certain areas of the West and Midwest, large-scale programs for the removal of carp have been necessary for the welfare of both fish and ducks. On one wildlife refuge, carp destroyed a newly planted 10-acre patch of chufa, devouring entire plants and making the water too turbid to permit seed germination to re-establish plant growths. While grubbing out vegetable material essential to ducks and geese, the carp stir up silt, which covers the eggs of desirable fish and prevents their hatching. When carp adversely affect the growth of plants, they also prevent the growth of many forms of small invertebrate life, such as the fresh-water shrimp, which are an important link in the food chain for game fish.

CONDITION FACTOR ALINEMENT CHARTS

Charles K. Phenicie
and
Clinton G. Bishop
Montana State Department of Fish and Game
Helena, Montana

IN THE past, fishery investigators have made wide use of the well-known cube law in measuring the condition or "degree of well-being" of fishes. The cube law, as used by fishery investigators, may be expressed by the following equation:

$$K = \frac{10^n W}{L^3} \qquad \text{(Equation 1)}$$

where

W = weight,
L = length,
K = condition factor,

and

10^n = factor to avoid use of small decimals.

Condition factor may be considered as a number that describes the robustness of fishes. Such a number has little value for only one group of fish: it is a relative figure and is useful in comparing one group with another. It has been used to measure the state of sexual development, the state of nourishment, and relative heaviness. The theory of the application of the cube law in computing a coefficient of condition of fishes, together with a literature review, has been given by Hile (1936). The present paper deals with a time-saving method of solving Equation 1.

By the use of logarithms, Equation 1 may be changed to the form,

$$\log K = n + \log W - \log L. \qquad \text{(Equation 2)}$$

Thus, in Equation 2 the expression is reduced to the addition forms, indicating the linear relationship between the logarithms of the values in Equation 1.

For many years alinement charts have been used in various fields of endeavor for solving some mensuration problems. An alinement chart may be defined as "a graphical mechanical representation of the relationship between two or more variables." The slide rule is a common example of an alinement chart. Chapman and Demeritt (1936) covered alinement chart construction and use. The present paper will deal with the method used by the Montana State Department of Fish and Game in giving graphical expression to Equation 2.

For studies of the sports fishery of Montana, the Department of Fish and Game measures the total length of fishes in inches and tenths of inches and the weight in pounds and hundredths of pounds. In Equation 1, n is taken as 5. For alinement chart construction, it was necessary to choose ranges for the values K, W, and L that would give the desired degree of accuracy and range coverage and still not make a chart so large that it would be unwieldy. It appeared that values from 10 to 100 would cover the needed range for K values and still give a K value of three significant figures.

Three ranges in weights were chosen (see charts A and B) for convenience in graph construction: 0.01 to 0.10 pound, from 0.10 to 1.00 pound, and from 1.00 to slightly over 3.00 pounds. These ranges in weight would cover nearly all the fishes encountered. The corresponding ranges in lengths were determined from Equation 1 after solving for L.

To reduce the error in plotting points, the three components of the charts were made on scales 1 meter long. Equation 2

was used in plotting the points; that is, log W, 3 log L, and log K were plotted, but the points were identified by their respective W, L, and K values.

The three components of each chart were arranged on a board. The distance between the K and W scales was chosen in proportion to the meter length of the scales, so that in the final reduction in size the dimensions of the graph would be of the desired size. The Department's duplicating machine set the final dimensions. The W and K scales were arranged on the board at the desired distance apart, set normal to lines connecting the extremes of the two scales. The L scales were placed normal to and with their extremes on these lines. To obtain their distances from the W and K scales, three W and K values for each chart were chosen for a single length; lines were drawn; and the corresponding lengths of the L scales were placed over the points of intersection.

The completed alinement charts were then photographically reduced to the desired size.

Computation of K values from the alinement charts is simple. A transparent straight-edge is placed on the length and weight values for any particular fish, and the K value is read directly from the condition factor scale.

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1936. Elements of forest mensuration. 2d ed. (revised), 451 pp. J. B. Lyon Company, Albany, New York.

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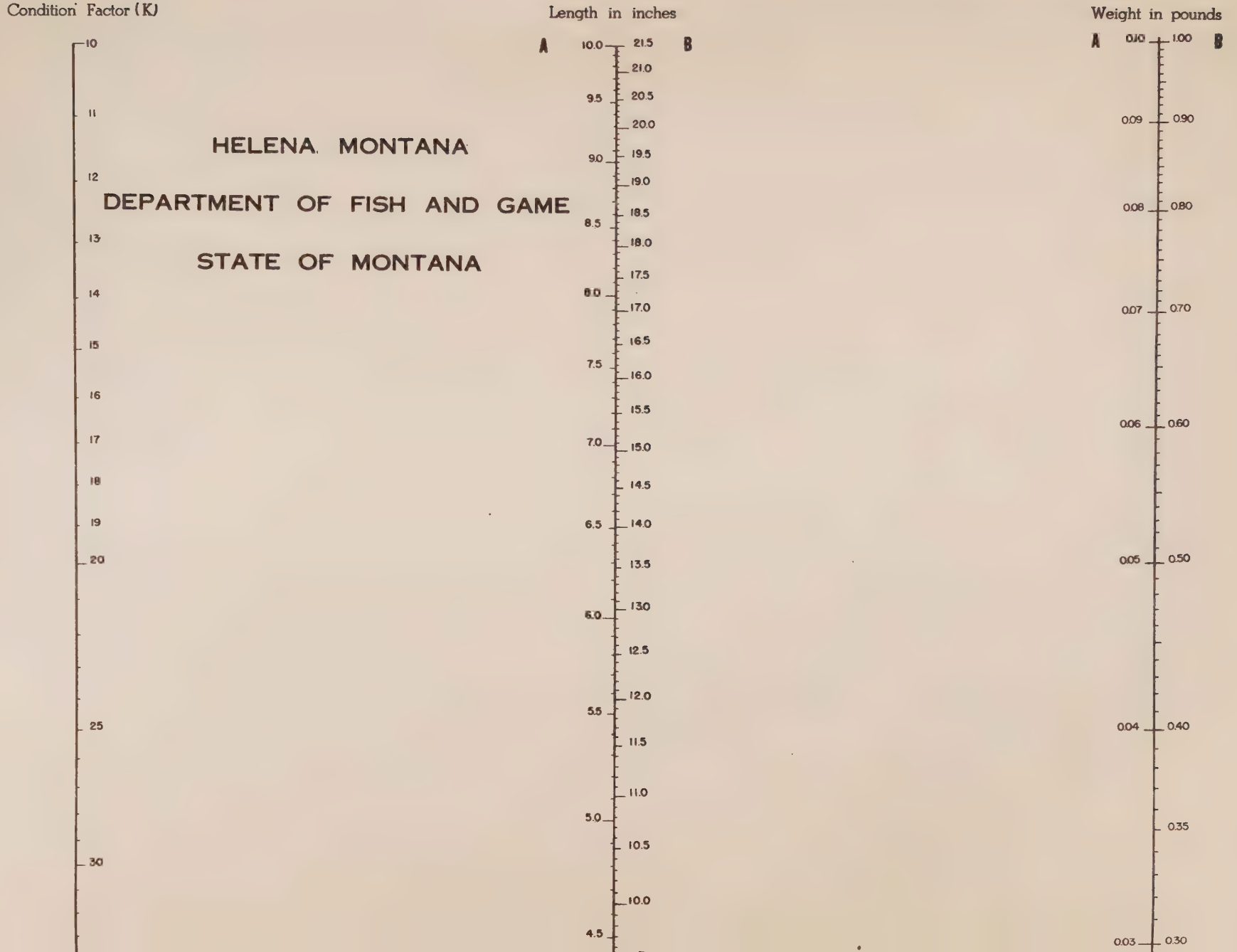
1936. Age and growth of the cisco, Leucichthys artedi (Le Sueur), in the lakes of the Northeastern Highlands, Wisconsin. U. S. Bur. Fish., Bull. 48 (19): 211-317.

A set of the Fish Condition Factor Alinement Charts appears on the following pages.--The Editors.

Some writers on the subject of the diseases of trout have recommended the use of a salt water bath. The fish, when they are affected, whether old or young, are transferred to a tank into which salt is gradually introduced, and it is said that this treatment will cure fungus. It is a dangerous remedy, a sort of kill or cure, that in desperate straits may be resorted to, but such straits should never be permitted to arise.

--R. B. Roosevelt and Seth Green, "Fish hatching and fish catching." Rochester, 1879.


Condition Factor (K)
Length in inches
A
B
Weight in pounds
A
B
HELENA, MONTANA
DEPARTMENT OF FISH AND GAME
STATE OF MONTANA
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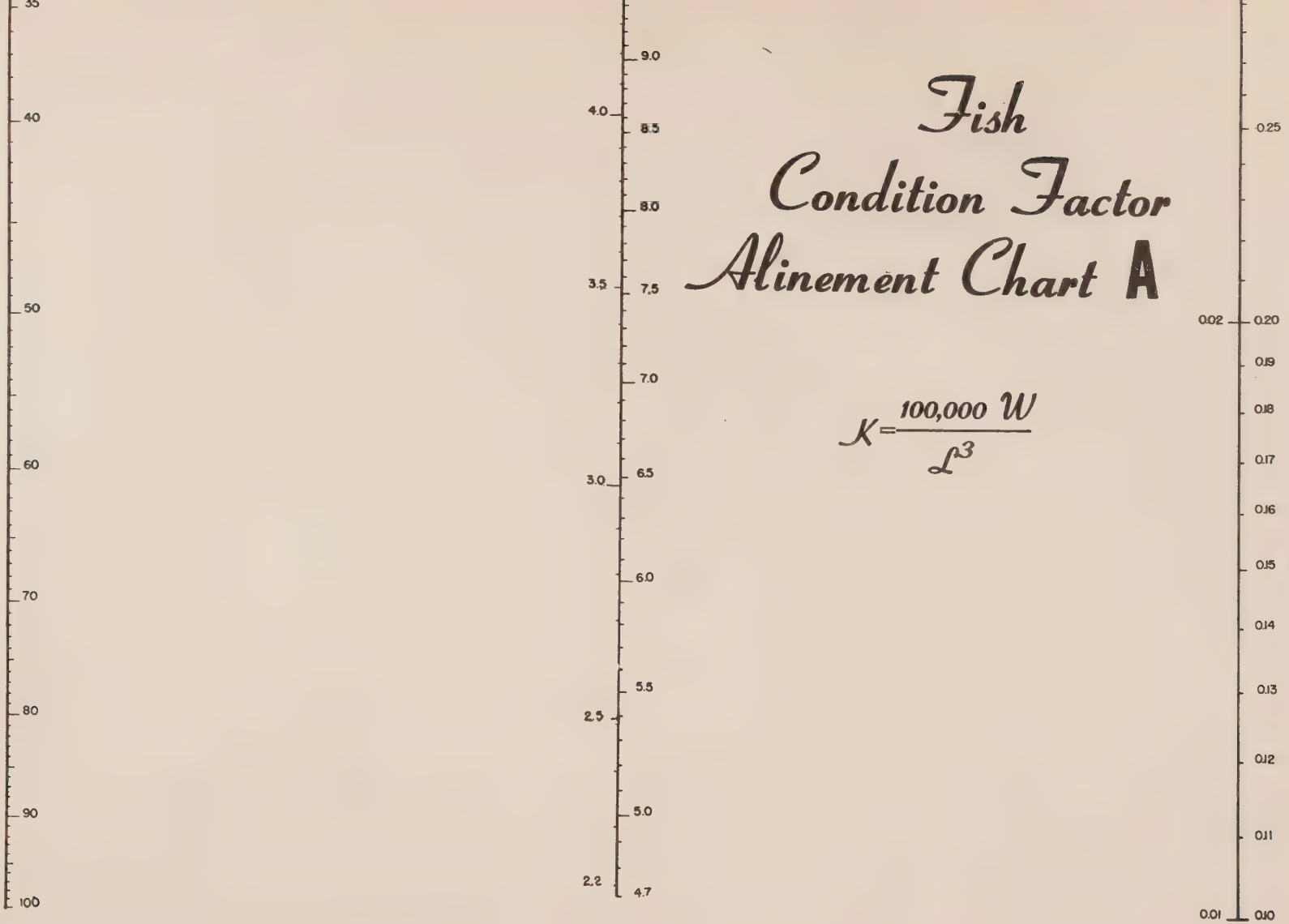
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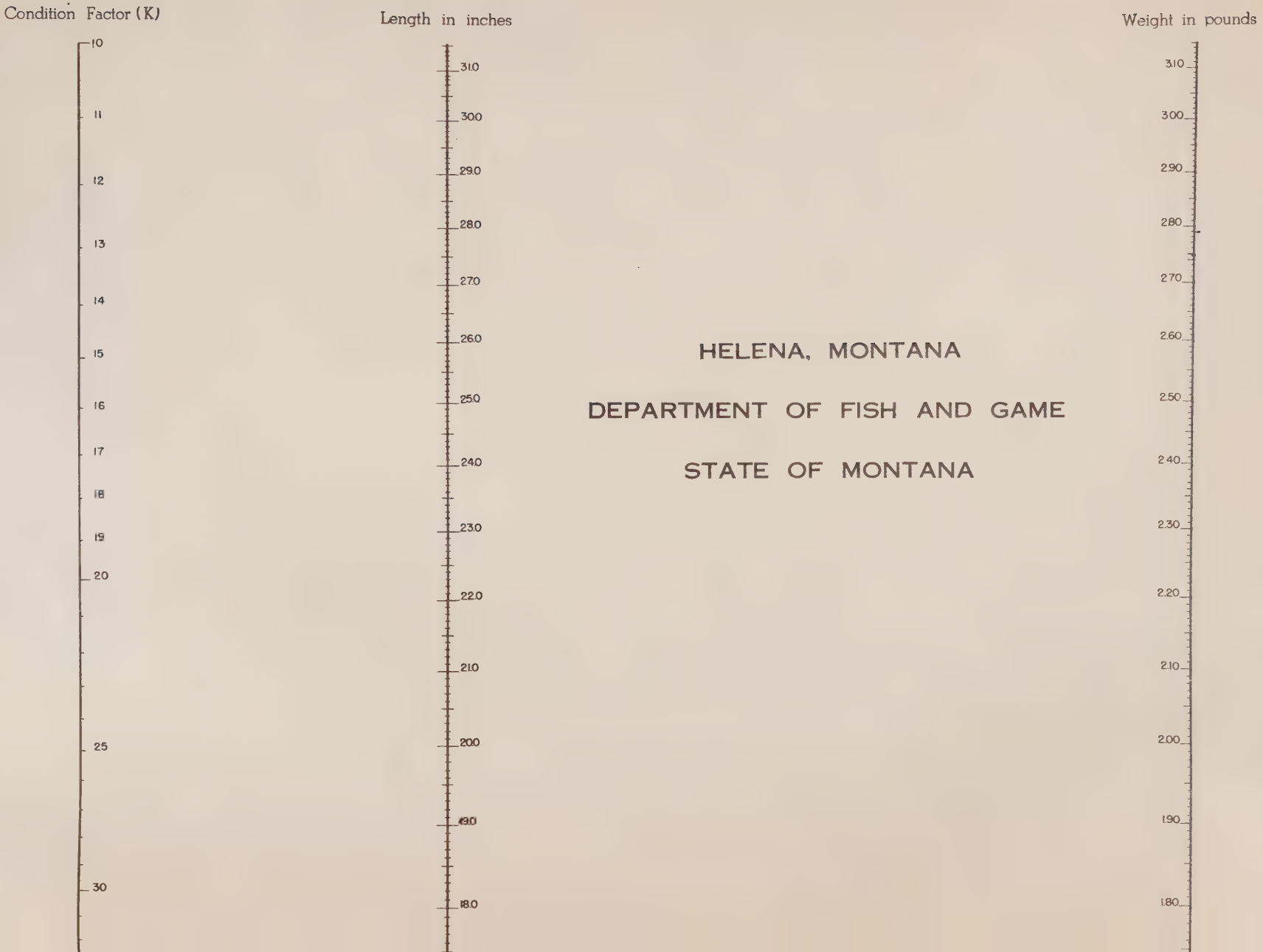
0.10
Fish
Condition Factor
Alinement Chart A
$K = \frac{100{,}000\ W}{L^3}$



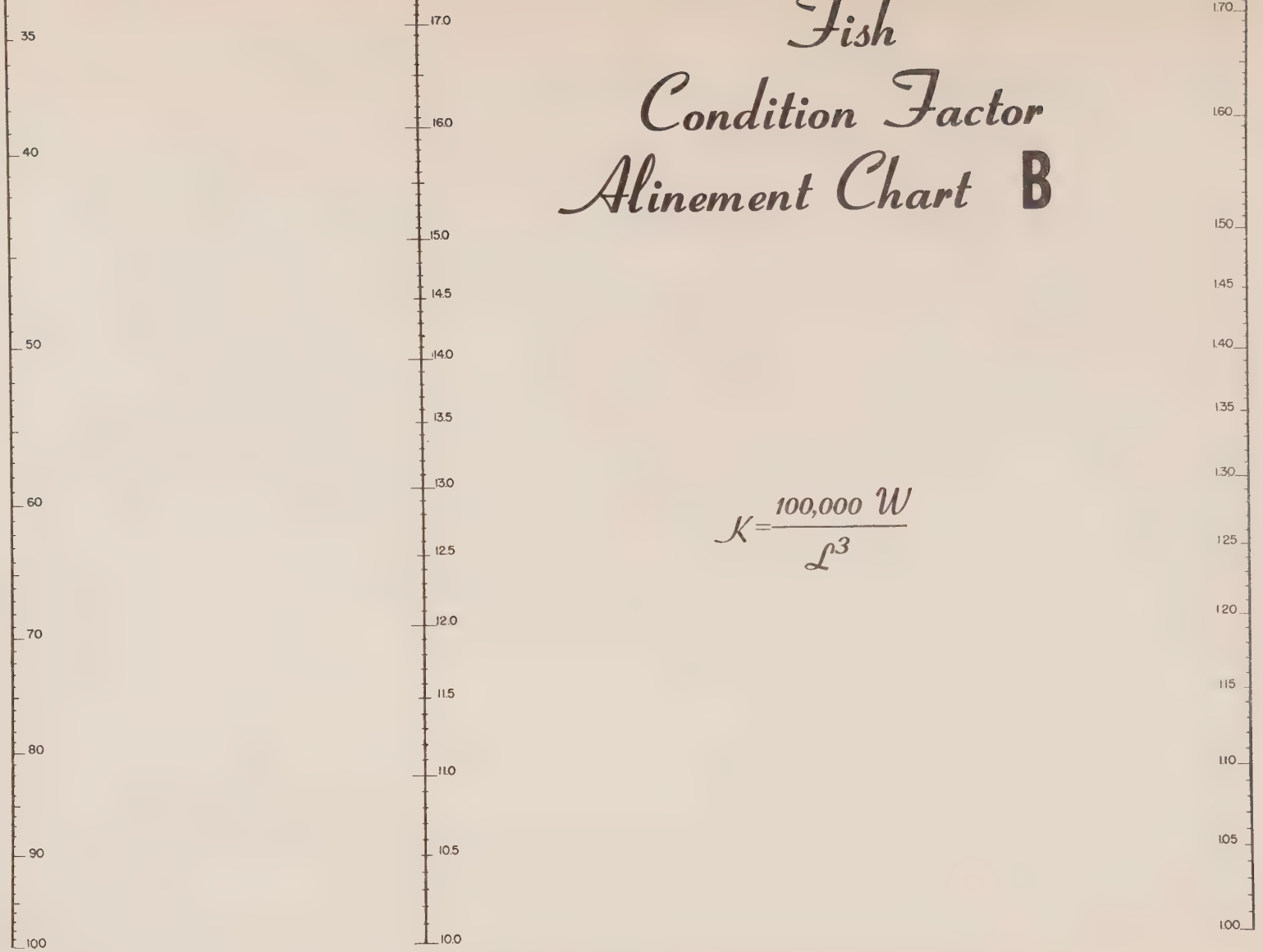
HELENA, MONTANA

DEPARTMENT OF FISH AND GAME

STATE OF MONTANA

JULY 1950

Fish Condition Factor Alinement Chart B



$$K = \frac{100{,}000\ W}{L^3}$$

DIET EXPERIMENTS ON ATLANTIC SALMON IN MAINE

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Lyndon H. Bond, Maine Department of Inland Fisheries and Game
Orono, Maine
and
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East Orland, Maine

IN THE summer of 1949, preliminary diet experiments were undertaken at the U. S. Fish-Cultural Station at Craig Brook (post office, East Orland), Maine. It has been difficult to produce a fingerling Atlantic salmon (Salmo salar) of uniformly good condition. It was believed that the meat level and Cortland No. 6 meal which had been fed might be less well suited to rearing Atlantic salmon than some modifications of this diet.

Physical Facilities

Rearing space available for diet experiments consists of 16 concrete ponds arranged in two rows so that the lower, even-numbered row of ponds is supplied with water from the upper, odd-numbered row of ponds. The upper row of ponds is supplied by individual 1½-inch holes from a common head line. Each of the 16 ponds is gravel-bottomed, 3 feet wide by 7 feet long, and has an average depth of 1 foot.

Diets Tested

Eight separate diets were tested in this experiment. These diets were composed of percentages of all or some of the ingredients listed in table 1.

During the test period, August 1 to December 9, the diets fed were as listed in table 2.

The dry ingredients of the meal mixtures were prepared in quantities sufficient for a month. The meat and meals were combined daily and weighed to the nearest gram.

Procedure

The Atlantic salmon used in the experiment were from Canadian Mirimichi River stock of the 1948 brood year.

The eight diets were randomized into upper and lower blocks (table 3).

Diet A1 was considered the control diet, as it is the standard trout diet that has been used in the past for Atlantic salmon.

It has been the custom at this station to carry through until fall about 15,000 salmon in each of the production rearing ponds. The area of the experimental ponds is equal to about 4 percent of the area of the larger rearing ponds; therefore, on July 13, 600 salmon fry were placed in each of the 16 diet experiment ponds.

On August 1, the salmon were large enough to consume dry feed mixtures and were changed from a diet of meat alone and were fed the special diets in the 16 ponds. The experimental salmon were fed a percentage of their body weight per day as follows:

		(percent)
August	-----	7.3
September	-----	5.2
October	-----	4.8
November	-----	2.7
December	-----	1.5

All ponds were fed with equal frequency throughout the day. The experimental ponds received the same number of feedings given in the other hatchery ponds.

TABLE 1.--Analysis of diet ingredients

Ingredients	Composition in percent[1]			
	Protein[2]	Fat[2]	Carbohydrates[2]	Fibre[3]
Dried buttermilk	32	5	-	None
Middlings	15	4	55	9.5
Cottonseed meal	-	-	-	-
Whitefish meal	58	5	-	-
Frozen beef liver (green or blue dyed)	-	-	-	-
Frozen hog spleen	-	-	-	-

[1] As given by the manufacturer of the ingredient concerned.
[2] Not less than.
[3] Not more than.

Because of the construction of the experimental ponds, it was not possible to clean or treat them efficiently; therefore, the block of 16 ponds was neither cleaned nor treated during the experimental period.

At the conclusion of the experiment on December 9, all salmon remaining in each pond were counted and weighed to the nearest tenth of an ounce (table 4). A sample of 30 fish was taken from each pond and preserved in 10 percent formalin to be used in obtaining an indication of size variation within the diets tested.

Results

The results of this diet experiment were judged upon survival and growth as listed in tables 4 and 5. An analysis of variance was calculated for the 16 ponds, including both number surviving and number per pound, at the conclusion of the experiment. The source and amount of variation are summarized in table 6.

The difference between meat levels was highly significant with a probability of 0.01, and the same can be said of the meals tested.

The graph indicates that, for all four meals tested, survival was better with the meat level high rather than low. It is noted that Diets A2 and B2, containing 70 percent meat, gave 11.5 percent higher survival than the standard Diet A1, which contained 45 percent meat.

It is indicated by table 5 that the salmon fed the 45 percent meat level were 7.5 percent lighter in weight and that

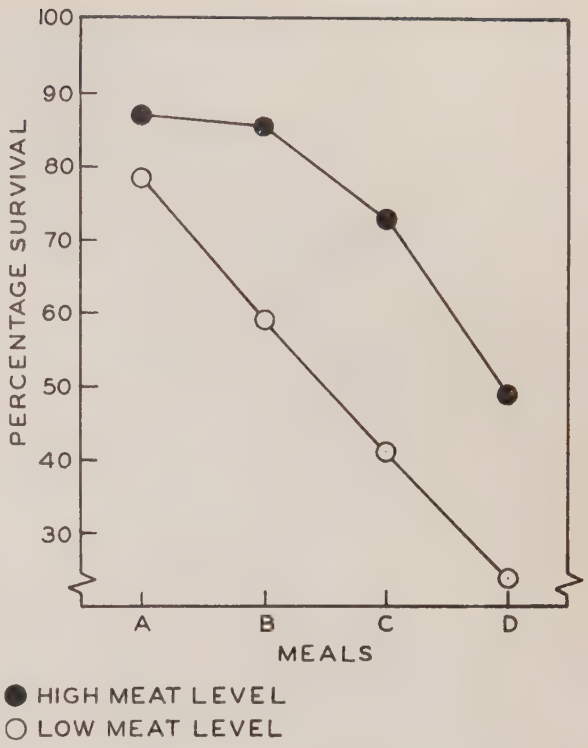
TABLE 2.--Percentage composition of diets by weight

Diet	Total diet			Meal-mixture composition				
	Beef liver	Hog spleen	Meal	Salt	Whitefish meal	Dried buttermilk	Cottonseed meal	Middlings
A1	15	30	55	4	24	24	24	24
B1	15	30	55	4	32	32	32	-
C1	15	30	55	4	48	48	-	-
D1	15	30	55	4	96	-	-	-
A2	15	55	30	4	24	24	24	24
B2	15	55	30	4	32	32	32	-
C2	15	55	30	4	48	48	-	-
D2	15	55	30	4	96	-	-	-

TABLE 3.--Diets as randomized in 16 ponds

Pond No.	Upper block	Pond No.	Lower block
1	A2	2	A1
3	C1	4	C2
5	D1	6	D2
7	B2	8	B1
9	C2	10	C1
11	D2	12	D1
13	B1	14	B2
15	A1	16	A2

their modal length was about ½ centimeter less than that of fish fed the 70 percent meat level.



Recommendations

It is recommended that:

1. Until new tests are run, the meat level fed the Atlantic salmon in this hatchery should be maintained close to a 70 percent minimum.

2. Further tests be run with meat levels above and below 70 percent.

3. Until further tests have been run,

TABLE 4.--Survival and number per pound

Pond No.	Diet	Number per pound July 13	Number surviving to Aug. 1	Number surviving to Dec. 9	Percent survival Aug. 1 to Dec. 9	Number per pound Dec. 9
1	A2	977.20	581	506	87.09	97.31
2	A1	985.22	542	481	88.74	94.31
3	C1	1,020.40	592	293	49.49	106.54
4	C2	1,015.22	561	480	85.56	93.20
5	D1	1,032.70	590	166	28.14	107.10
6	D2	1,048.95	552	359	65.04	101.12
7	B2	1,020.41	581	496	85.37	97.25
8	B1	986.84	542	382	70.48	96.71
9	C2	1,071.43	592	356	60.14	86.83
10	C1	1,058.20	570	189	33.16	94.50
11	D2	1,054.48	596	196	32.88	95.61
12	D1	1,030.92	589	138	23.43	125.45
13	B1	1,011.80	589	284	48.22	91.61
14	B2	1,003.34	499	439	87.98	90.52
15	A1	1,016.95	559	382	68.34	94.32
16	A2	972.45	528	463	87.69	91.68

meal A (Cortland No. 6) should be used whenever meal is incorporated in the diet.

4. Further diet tests include trial of vitamin supplements in the diets.

TABLE 5.--Means of percent survival and number per pound

Meat level in percent	Meals A	B	C	D	All meals
	..... Percent survival				
45	78.54	59.35	41.32	25.78	51.25
70	87.39	86.68	72.85	48.96	73.97
	..... Number per pound				
45	94.32	94.16	100.52	116.28	101.32
70	94.50	93.88	90.15	98.36	94.19

TABLE 6.--Analysis of variance

Source of variation	Degrees of freedom	Percentage survival Sum of squares	Mean square	Number per pound Sum of squares	Mean square
Total (16 ponds)	15	8,559.8216	570.6548	1,250.3654	83.3577
Upper and lower blocks	1	424.4631	424.4631	7.45	7.45
Within diet (error)	7	1,019.6042	145.6577	320.3605	45.7658
Meat levels	1	2,064.5665	2,064.5665[a]	203.205	203.205
Meals	3	4,759.8698	1,586.6233[a]	491.3237	163.7746
Meat vs. meals	3	291.3180	97.1060	228.0262	76.0087
Between diets	7	7,115.7543	1,016.5363	922.5549	131.7936

[a] Highly significant probability, of less than 0.01.

A biologist working in Oklahoma reported recently that one red-breasted merganser that had found it easier to rob the net in an experimental study than to do his own fishing, got caught in a gill net 15 feet below the surface.

PUBLICATIONS

REPRINT

EFFECTIVENESS OF MODERN FISH MANAGEMENT PRACTICES: PLANTING

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To cover adequately the oldest, most revered, most debatable, and most expensive of fishery management procedures in a panel discussion is difficult if not impossible. The problems of fish planting will, therefore, be considered in broad outline with an abridgment of supporting details. Until the last decade most of the resources available for freshwater fishery management which were left over from enforcement of regulations were poured into hatchery programs. Success of these operations was judged by the quantity of fish which could be placed in lakes and streams without much regard for the extent of actual contributions to the anglers' catch. The faith in this procedure held by both fishermen and administrators was engendered by the successful establishment of desirable species in many barren waters and the creation of excellent fishing in areas where none previously existed. Although it was suggested as early as 1900 by a high official in the U. S. Fish Commission that planting for maintenance was impractical, it was not until the early nineteen thirties that forward-looking state administrators sponsored adequate research to determine the role of planted fish in the maintenance of good fishing. Now after about fifteen years of investigation all administrators and the interested public should take full stock of the situation and approach the whole problem of artificial propagation with a realistic attitude and apply to it the hard-headed economic analysis which any major operating expense merits. The necessity for immediate consideration is occasioned by post-war expansion of fishing activity, availability of increased funds, and mounting demands for more active management which face most administrators. In addition, the probable passage of some federal aid bill similar to H. R. 1693, known as the Dingle Bill, which was presented to the 80th Congress, will make federal funds available for fishery development.

The only valid objective of fishery management and administration is to produce the maximum sustained yield of fish from public waters and insure equitable and economic distribution with a minimum cost; or, in the angler's words, to produce the shortest time between bites with available license dollars. It is therefore highly important that we be prepared to utilize existing and prospective funds for real fishery improvement rather than for maintenance or extension of existing plants if they are of questionable value.

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The problem boils down into two questions: (1) will artificial stocking result in an annual take of more fish, and (2) if so, is this procedure the most economic one for producing the increase? Too frequently local and limited success in the application of hatchery products obscures the fact that a large percentage of the financial resources available for an entire state or area has been expended to achieve an insignificant addition to the total fish produced in this area. In other words, the apparent success, when judged on a basis of state-wide production, may assume rather puny proportions. With these considerations in mind, we can proceed to a summary of the facts regarding the efficiency of artificially reared fish in the maintenance of good fishing. For convenience of discussion we can consider stocking procedures under three divisions: (1) stocking for maintenance of commercial fisheries; (2) stocking of warm-water game species; and (3) stocking of trout.

Commercial Fisheries

For many years extensive hatchery operations have been conducted for the benefit of fresh-water commercial species. This activity has been most vigorously prosecuted in the waters of the Great Lakes, some of our border waters, and the great inland rivers. The present discussion will omit stocking which has been done in coastal streams for the maintenance of anadromous species, although, with certain exceptions to be noted later, the story is approximately the same as in inland waters.

Doubt was first cast on the effectiveness of hatcheries for maintaining commercial species because it was recognized that the number of fish which could actually be stripped and their eggs hatched artificially was only an infinitesimal proportion of those fish which must spawn naturally in the lake. One of the first critical analyses was made by Hile (1937) on the effectiveness of yellow pikeperch plantings in the Great Lakes. By comparison of hatchery plants with commercial production several years later when these fry would be of a size to influence the commercial catch, he showed that years of heavy planting were not followed by years of heavy production and that, in fact, the reverse appeared to be true; that is, that following the years of heaviest planting there was the lowest commercial production. This work was followed by work on the whitefish in Lake Erie carried on by Van Oosten (1942), further investigations in the Red Lakes (Van Oosten and Deason MS), Lake of the Woods in Minnesota (Carlander, 1945), and most recently by Miller (1946) on whitefish in Alberta. This last worker showed that it was possible to establish a commercial fishery by planting whitefish fry in barren waters but that continued plantings did not benefit later commercial yields. Wherever an attempt has been made to correlate continued fish planting and subsequent commercial production, no significant relationship has been established.

A possible reason for the apparent failure of hatcheries to influence commercial yield may be found in the investigations of Langlois (1945). He pointed out that in Lake Erie the number of pikeperch fry planted was only about 0.0006 per cent of the spawn which must have already been produced by those fish taken in the commercial catch of any one season. Apparently in this case even the most vigorously prosecuted hatchery program could add fry in numbers which must be considered a "drop in the bucket." Miller (op. cit.) arrived at the same conclusion for whitefish. It has been suggested that rearing lake trout to fingerling size before planting would result in a greater survival and consequently a greater influence on the commercial catch. To test the significance of this theory, an extensive experiment with marked fish is now in progress on the Great Lakes. Regardless of the outcome of this experiment in terms of percentage survival of planted fish, the true analysis will be based upon the percentage influence which planted fish can have on the total take. The arguments which have waxed loud and hot over the survival of planted fish frequently overlook the fundamental problem concerning the influence these fish have on the total catch. Critical analysis has suggested that the survival which

is observed is usually at the expense of native reproduction. In view of scientific data assembled to date, I think it can be said that hatcheries have contributed little if anything to the maintenance of the catch of fresh-water commercial species.

In certain anadromous species such as the Pacific salmon, recent successes in the re-establishment of runs eliminated by the construction of dams have been noted especially by Fish (1948) in the Columbia River. This success, which is comparable to that found in stocking of barren waters, should not be confused with maintenance plantings where we try to substitute hatchery stock for natural reproduction in waters containing ample spawners. Further discussion of the problems of anadromous fish would be very interesting and profitable, but it is beyond the scope and purpose of the present paper. Some planting has been done in our great inland river systems, but aside from the introduction of species above barriers no correlation between planting and commercial yield has been definitely established.

Warm-water Game Species

Following the trail blazed by early fish-culturists who worked with trout and anadromous forms, large hatcheries were established for the production of warm-water species to introduce and maintain fish for sport purposes in inland waters. Stripping and jar hatching of such fish as yellow pikeperch has been very extensively employed, and the pond production of centrarchid fishes has been developed to a high point. It is an undeniable fact that species such as yellow pikeperch and black bass have been widely distributed and established in waters where they did not previously exist, and in these waters they have sometimes created excellent fishing. It should also be pointed out, however, that this good fishing for the introduced species has sometimes been at the expense of the native species. Wide use was made of artificially reared warm-water fishes in the stocking of farm ponds and reservoirs, or other artificially created and barren waters. Proper application of these initial stockings has resulted in very satisfactory results, particularly in river systems where desirable species did not already exist. The extensive development of the farm fishpond has been dependent to a large extent on the availability of hatchery-reared fingerlings for seeding these waters.

Current misapplication of hatchery efforts does not involve these new or barren waters but is centered in the attempts to increase fish production from natural bodies of water where adequate spawning stock of the planted species already exists. Careful investigations by Bennett (1943) of Illinois, Carbine (1937) and other workers at Michigan, Eschmeyer (1944) and his colleagues in the impounded waters of the TVA system, workers in Ohio, and our own extensive work in Minnesota have shown that the problem of warm-water fishes is not one of inadequate reproduction but one of inadequate utilization. Hatchery fish when applied to overcrowded waters may aggravate situations already bad and do little or nothing toward improvement.

Fry planting of warm-water species for maintenance of sport fishing has proved to be entirely useless except where new waters or waters otherwise completely denuded of fish can be rehabilitated by such introductions. Unfortunately, in the past fry planting has been carried on at a tremendous tempo in the Lake States and Upper Mississippi Valley to maintain fishing in waters which already had brood stock. A rather significant study carried on in Minnesota showed that, assuming minimum survival of pikeperch fry from natural spawn, one of our large lakes produced almost as many fry annually as the entire hatchery plant of the state produced and distributed in several hundred lakes. We are again confronted here by the "drop in the bucket" situation which was pointed out by Langlois in Lake Erie.

Some states are now embarking on an expansion of hatchery programs designed to rear certain predaceous fishes such as yellow pikeperch and northern pike to fingerling size for restocking public waters which have had a reputation for

production of these species but which now appear to be depopulated. What success will attend these experiments is difficult to predict at this time. Contrary to the public belief in areas where this development is taking place, fishery technicians do not think that waters with an adequate spawning stock will be materially affected or benefited. There is ample evidence that reproduction is excellent in many of the waters where the greatest hue and cry for planting is being raised. It is believed that the only practical use of such reared fingerlings will be to re-establish a population structure favorable to natural reproduction or to produce fishing for planted stock in waters primarily suited to some other species. In the first situation it is an open question whether intensified exploitation, commercial or otherwise, of the unused species might not be more effective. The important aspect of this program, however, is the fact that a great development is being made before any critical proof exists that it will in any way accomplish the results desired. It is entirely possible that these states will find themselves with a large hatchery set-up of no value for the maintenance of good fishing but one which for administrative and political reasons they cannot abandon.

Observed in its broad aspect, current information indicates that planting of warm-water species in areas where adequate brood stock exists is of little value or downright harmful. New or barren waters can be benefited and possibly population structures may be altered favorably by large introductions of predaceous fish.

Trout

The third and perhaps most important aspect of propagation we must consider is the use of artificial stock in the maintenance of trout streams and trout lakes. Since the greatest expenditure and the most effort go into production of trout for stream stocking, it will be our primary consideration. We are here faced with a problem differing greatly from that of the warm-water fish lake. Trout streams are on the average less productive and much more heavily fished than the majority of lakes. To maintain good fishing in the face of this situation is the principal justification for the trout hatchery. Because trout have always received the most consideration from fish-culturists and administrators alike, changes in established practice are difficult to accomplish. To tell an accomplished fish-culturist who has devoted his life to the production of better trout fingerlings that his efforts have little effect on stream fishing, is not only to insult and alienate him but to face a barrier of disbelief and organized opposition to constructive new policies. Facts developed in the last few years, however, call for a revision of practices and, above all, a revision of the economic approach to the problem. The mere fact that outstanding examples of bettered trout fishing through use of legal-sized hatchery fish can be cited does not alter the fact that from an economic standpoint such intensive management is questionable.

Until the middle of the last decade, most planted trout were fingerlings. When use of this size failed to give results, experiments with catchable-sized fish were tried and in proper circumstances were found successful. There was a swing to this type of management, but many states still plant fingerlings extensively. That such planting is uneconomical and with few exceptions has failed to improve the anglers' catch, has been quite well established by Shetter (1939) in Michigan who found an average survival to the creel of about 1 per cent, by Surber (1940) who demonstrated a 2.4 per cent survival, and by Chamberlain (1943) on the Pisgah who showed that fingerlings not only failed to improve fishing but were actually a detriment. Needham and Slater (1944) in California showed that natural mortality of fingerlings both native and planted was so great that the contribution of planted fish did not improve the total number of catchable-sized fish in the stream. With limited exceptions where there is no natural facility for reproduction or where heavy fishing reduces brood stock below the minimum required for adequate reproduction, investigations indicate that fingerling

planting of trout in streams does not result in increased angler success. The story is again one of natural reproduction outstripping the hatchery products. Schuck (1948) has demonstrated that ineffectiveness of hatchery trout is caused in part by their poor ability to compete in the natural environment. Whatever the reason, the fact remains that hatchery fingerlings do not improve the fishing.

Many examples of improvement to anglers' creels can be cited where legal- or catchable-sized fish are regularly stocked. Recoveries to the angler may run as high as 90 per cent in individual plants and may average as high as 80 per cent in intensive management areas like the Pisgah and Natahala areas in the southern Appalachians, but nation-wide averages of returns from marked and planted legal fish run around 25 per cent. When anglers come home from these planted streams with a well-filled creel, they hail the planting of such trout as the answer to better fishing.

When we analyze this type of management, three concepts must be kept in mind: (1) we are trying to make possible the harvesting of a greater crop from streams than nature will produce from them; (2) we are not managing a natural resource but are creating an artificial recreational resource comparable to public golf links or public baths; and (3) the justification for expenditures should be based on how much the total trout production of the state or management area is increased.

Current estimates on the cost of producing legal-length trout vary considerably since, unfortunately, most states do not have adequate cost accounting systems which include all expenses. If capitalization costs on the hatchery plant are ignored, the cost of each 7- to 10-inch fish placed in the stream is 25 to 50 cents. On the basis of known percentage returns from planted fish, this means that each fish in the angler's creel will cost from 30 cents to $2.50 each, or $1.50 to $12.50 per pound. In most states the resident angler's license does not exceed $2 and is usually less. About half of this fee will go for law enforcement, education and general overhead, leaving about a dollar or less for planting, stream improvement, noxious fish control, etc. This means that when an angler has caught one to four hatchery fish, he has exhausted his contribution to trout stream maintenance. Careful checks have also shown that one-fourth to one-third of the anglers may take as much as three-fourths of all planted fish which are eventually returned.

Among administrators who recognize these facts, I have frequently heard the comment that a good artificially maintained stream where a man can catch his limit is an excellent show window for the department and helps win support for the more constructive if less easily understood policies of the administration. This may be so, but in that event its cost and effectiveness should be compared to that of other modern advertising media.

Recently considerable success has been noted by Hollaway in Oregon, Taft (1947) in California, Shetter (1947) in Michigan and others in the planting of advanced trout fingerlings or, in some cases, fry in suitable lakes either barren of fish or containing less desirable species. In these lakes natural reproduction is usually poor or absent and continual planting must be carried on to maintain fishing. Returns of above 50 per cent in the case of fingerlings and as high as 88 per cent in the case of catchable-sized fish have been noted. Wales (1946), making estimates on California lake fishing prior to present price increases, figured that each trout in the angler's creel cost 13 cents. Even at this cost one limit of fish was all the license holder was entitled to (Taft, 1947). The creation of trout lakes and their continual maintenance is usually justified on the basis that there are inadequate natural areas to carry the fishing load. That such management has a place in the general picture is well established.

Conclusions

What conclusions are to be drawn from these facts? First, in areas where license fees alone are used for maintenance, a small percentage of anglers are reaping the benefit from hatchery activities and

nature, as usual, is supporting the bulk of the anglers. In other words, the license holders in general are supporting a relatively few anglers in a luxury to which they have no claim. Second, a realistic approach to the problem of planting calls for much higher trout license fees or, preferably, permit fishing on carefully managed areas like the Pisgah where the trout fisherman can acquire any amount and quality of "put and take" fishing his pocketbook will stand. Third, since application of the "Pisgah System" is impractical or impossible in the majority of public waters, a more effective use of the present inadequate license dollar on a state-wide basis would be the improvement of trout habitat, including soil control, pollution abatement, and physical adjustment of the stream channel itself. Fourth, probably most important of all, is the development of accurate cost accounting and the education of license holders in the price they pay when they get better fishing by continued planting as compared to other methods of management.

In considering some of the drastic changes implied by the foregoing conclusions, I do not minimize the difficulties of securing public acceptance of these ideas and translating them into administrative practices. A number of years' service in administrative agencies has shown me that new constructive ideas cannot be employed until our "customers," the license holders, are educated to accept them. On the other hand, nothing irritates a sensible man like the belated realization that he has paid through the nose for something he thought he was getting at a bargain.

In summarizing the current status of fish planting as a management practice, I am aware that limited local circumstances may be at variance with the generally applicable facts. This circumstance only emphasizes the need for a realistic and unprejudiced approach to the problem in every state. To review the whole question at a glance, it may be said that in the light of current knowledge: (1) planting for maintenance of commercial species has so far proved to bear no relationship to the volume of subsequent production; (2) warm-water fish planting except in new or barren waters is either useless or of unproved benefit; (3) fingerling trout planting in streams does not improve fishing significantly; and (4) catchable-sized trout planting is very costly and is economically justified only in management areas where it can be made self-supporting. The logical development of these ideas does not mean the abandonment of hatcheries, but it does require a realistic analysis by administrators and education of the public so that they know what they get for their hatchery dollars.

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REVIEW

THE FISHERMAN'S ENCYCLOPEDIA

Edited by Ira N. Gabrielson and Francesca LaMonte. xxix + 698 pages. Stackpole and Heck, Inc., New York, 1950. $12.50.

I have not read The Fisherman's Encyclopedia. Time has not permitted. Nor could anyone read it straight through, any more than could one person consume a banquet for five hundred. Such rich fare must be taken piecemeal and digested at leisure. But I have examined it sufficiently to be convinced that it will provide pleasure, satisfaction, information, and inspiration for the thousands who will read parts of it through the evenings of an entire winter.

The book is compiled from the writings of sixty-five contributors--scientists, sportsmen, outdoor writers, manufacturers' and association representatives, and Government experts--all of whom speak with authority and assurance in their own respective fields. Although the material has been woven together by the editors to make it a comprehensive--and I mean comprehensive--account of fishing in fresh and salt waters, chiefly in North America, the style, treatment, and scope of detail in these articles vary considerably throughout the book. From Corey Ford's beautiful and poetic foreword explaining the deep-seated reason why people fish, the reader plunges abruptly into a 26-page introduction, "Fish Biology and Evolution" by William K. Gregory, which is as technical as might well be expected from the Curator Emeritus of Fishes and Comparative Anatomy, American Museum of Natural History. Differing from many encyclopedias, this one is not all a plodding recital of facts and figures. There are too many items of pure interest to mention individually, but it would be difficult to find a more gripping and dramatic story of action and suspense than the one on surf fishing or a more thoughtful, better-balanced, and more down-to-earth discussion of fish management than the one presented.

Section 1 is a catalogue of the game fishes of America, giving approved names, range, coloring, size, food habits, and similar information on the important fresh-water and salt-water species. Section 2 deals with fishing equipment and fishing methods. Section 3 describes craft for fishing. Section 4 deals with fishery-management methods; Section 5, with where to fish; Section 6, with when and how to fish; and Section 7 is a stew of miscellaneous topics, all concerned with fishing. There is a brief section on building a fisherman's library, a glossary of technical terms, and an adequate index.

Apparently, everything which might conceivably be related to the sport of angling has been included, but the length of treatment is not always related to the significance of the subject. The editors have even included four pages of a highly persuasive but scarcely convincing sales talk on the "solunar theory." There is a satisfying section on fishing craft and an equally detailed discussion on the making of fishing lures. The section on where to fish, which provides an angling guide for the several provinces of Canada, Alaska, Mexico, and apparently each of the United States, with special notes

on the National Parks, seems repetitious but, nevertheless, serves a useful purpose for anyone who takes his fishing seriously enough to travel great distances.

Apparent errors and deficiencies are few and minor. The authoritative character of the treatment of many of the separate subjects would have been enhanced had each contribution been identified by the writer's initials as is so often done in encyclopedic works. Although the half-tone illustrations are generally poorly executed (the photographers who supplied the many hundreds of snapshots of fishing scenes and fishing trophies should have read the excellent section on photography for fishermen) and the color illustrations are very much over-colored, the format of the book is generally good, the quality of the paper is fine, the type is very clear, and the binding is handsome and durable.

It remains for the readers and users of the book to determine for themselves whether the technical sections are scientifically accurate in all respects (ichthyologists are notorious disagreers), whether fishing conditions in some familiar local spot are as good as described, and whether the recommended methods apply (fishermen also disagree). This should lead to endless arguments well worth the price of the volume.

Elmer Higgins.

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